The Nation's Renewable Resources- An Assessment, 1975

U.S. Department of Agriculture ▪ Forest Service

Forest Resource Report No. 21

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U.S. Department of Agriculture
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June 1977

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FOREWORD

This Assessment, the first comprehensive study of the renewable resources of forest, range, and inland waters, has been prepared in response to provisions of the Forest and Rangeland Renewable Resources Planning Act of 1974. It shows that the Nation's demands for outdoor recreation, wildlife and fish, forest-range grazing, timber, and water have been growing rapidly. These demands, in response to increases in population, economic activity, and income, continue to rise in the decades ahead.

Although there are differences in the projected growth in demand for the various products, the increases are substantially above the levels that can be supplied with present management programs and the existing physical facilities. Thus, we are faced with the prospect of rising costs for products such as timber, forage, and water, and intensifying competition for the available supplies of wildlife, fish, and outdoor recreation.

This study shows that this outlook can be changed. There are many opportunities on the 1.6 billion acres of forest, range, and inland water to increase, extend, and improve supplies of products. For example, these lands and waters have the physical capacity to supply sites for most types of outdoor recreation well in excess of expected increases in demand and to support much larger numbers of most species of wildlife and fish. Under intensive management, the forest and range lands have the capability of producing nearly three times the volume of forage and in time more than twice the volume of timber grown today.

With proper management, the greatly increased levels of output can be maintained for the benefit of future generations. In appraising the need for action, this is a major consideration. For in the longer run, with growing pressure on the environment and nonrenewable stocks of ores and fuels, renewable resources will surely become increasingly important to our economy and society.

JOHN R. McGUIRE
Chief

PREFACE

This assessment has been prepared in response to the provisions of Section 2 of the "Forest and Rangeland Renewable Resources Planning Act of 1974" which directs the Secretary of Agriculture to ". . . prepare a Renewable Resource Assessment . . . the Assessment shall be prepared not later than December 31, 1975 and shall be updated during 1979 and each tenth year thereafter, and shall include but not be limited to:

> (1) An analysis of present and anticipated uses, demand for, and supply of the renewable resources of forest, range, and other associated lands with consideration of the international resource situation, and an emphasis of pertinent supply and demand and price relationship trends;
>
> (2) An inventory, based on information developed by the Forest Service and other Federal agencies, of present and potential renewable resources, and an evaluation of opportunities for improving their yield of tangible and intangible goods and services . . ."

In accordance with these provisions, this study provides an analysis of the present situation and the outlook for (1) outdoor recreation and wilderness, (2) wildlife and fish, (3) forest-range grazing, (4) timber, and (5) water. It includes statistical data on the ownership, condition, and productivity of the Nation's 1.6 billion acres of forest and range lands and associated inland waters; recent changes in forest, range, and inland water resources; trends in the consumption and prices of major products; the prospective demand, supply, and price outlook to 2020; and opportunities for increasing supplies of products and improving productivity. Data are also presented on international trade in forest and range products and the forest resources of important trading countries. The last chapter of the study discusses the kinds of data and scientific information needed to provide an adequate quantitative basis for future assessments of this kind and for the determination of the sizes and combinations of programs that would most effectively and efficiently meet the Nation's future demands for forest, range, and inland water products.

The projections of demand as used in this study indicate the amount of the product likely to be consumed or used under alternative assumptions on population, economic activity, prices, and other determinants. The supply projections show the amount of the product that will be available for consumption or use if recent trends in investments in management, utilization, and research programs continue through the projection period.

A comparison of these projections provides a measure of prospective future imbalances between demands and supplies, given the underlying assumptions, and an indication of the kinds and sizes of programs that could bring about a desired supply and price situation. These comparisons, along with current and historical statistical data, also provide a basis for appraising ongoing forestry and range programs and an indication of opportunities for economic development of forest and range resources.

In recent years, many and rapid changes have taken place in the use of American forest and range lands and inland waters. Consumption of nearly all products of these lands and waters has been rising rapidly, and there has been increasing emphasis on management for multiple purposes. There has also been growing concern about the forest and range environment and the need to preserve and enhance scenic and esthetic values.

An effort has been made to recognize changes that have been taking place and likely impacts on future supplies of forest, range, and inland water products. For example, constraints associated with multiple use management and protection of the environment have been taken into account in projecting timber supplies from the National Forests. Projections for private ownerships also recognize the importance of nontimber objectives and that timber harvests might be limited. Specific allowances for continuing transfer of commercial timberlands to other uses were made on all ownerships.

The analysis in this study covers the next four and a half decades. For the longer run, with growing

population pressure on the environment and nonrenewable stocks of ores and fuels, renewable resources could become increasingly more important. Thus, in appraising the needs for programs and the urgency for action, consideration must be given to the situation beyond the period covered in this report. With proper management, the output of renewable forest and range products can, in time, be greatly increased and higher levels of output maintained for future generations.

ACKNOWLEDGMENT

Many members of the Forest Service, other Federal agencies, State agencies, and conservation and industrial organizations have contributed to this study. The names of the principal authors and other significant contributors to the individual chapters are listed below.[1] The help of all others who compiled material or who contributed is also gratefully acknowledged.

The principal author of Chapter I, "Basic Assumptions," and Chapter II, "Forest and Range Land," was Dwight Hair. Significant contributions to Chapter I were made by H. Fred Kaiser, Robert B. Phelps, and Robert N. Stone. Significant contributions to Chapter II were made by Charles C. Van Sickle, Jack E. Schmautz, Gary L. Tyre, Howard E. Banta, and Robert N. Stone.

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The principal author of the final draft of Chapter IV, "Wildlife and Fish," was Dennis L. Schweitzer, except the section on waterfowl which was authored by Wilbur N. Ladd, Jr. (Fish and Wildlife Service). The initial draft of this chapter was prepared by Jack W. Thomas, Michael R. Lennartz, and David P. Worley. Significant contributions were made by Phillip B. Summers, Gary R. Lindell, Jerry P. McIlwain, Hewlette S. Crawford, Jr., Dale R. Potter, Richard M. Degraaf, Brian R. Payne, and William R. Meehan.

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The principal authors of Chapter VI, "Timber," were Dwight Hair and Robert B. Phelps. Significant contributions were made by R. Bruce Anderson and Thomas C. Marcin.

The principal author of Chapter VII, "Water," was Adrian L. Haught. Significant contributions were made by Marvin C. Meier and Samuel I. Becker.

Significant contributions to Chapter VIII, "Scientific Information and Data Needs," were made by Joseph E. Barnard and Charles C. Van Sickle—material on inventories of forest and range land resources; Thomas J. Mills—material on physical responses of resource systems to changes in management practices; Charles T. Cushwa and Lawrence C. Davis (Utah State University)—material on development of a land classification system; Dean N. Quinney—material on surveys of use of forest and range products and of forest and range product prices; and Kenneth D. Ware, Lawrence C. Davis (Utah State University), Gary H. Elsner, Michael J. Penfold, Ernst S. Valfer, and Ross S. Whaley (University of Massachusetts)—material on techniques of collecting data and scientific information, projecting longrun trends in demands and supplies, impacts of changes in demand-supply relationships, establishing goals and objectives, and management decision and program formulation.

Dwight Hair was the study manager and participated in the preparation of much of the text. J. Louise Parker, Susan J. Branham, and William P. Everard also assisted in text preparation.

[1] Contributors are Forest Service employees unless noted.

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HIGHLIGHTS

In response to past increases in population, economic activity, and income, the demand for nearly all products of forest and range lands, and the associated inland waters, has risen rapidly. The growth has been especially fast for some forms of outdoor recreation. For example, the number of households camping more than tripled between 1960 and 1973, increasing from 4.3 million to 14.3 million. Increases for most other products were more modest but substantial. Between 1960 and 1970, the days spent hunting and fishing rose from 563 million to 771 million, a rise of 37 percent. Timber consumption grew from a level of around 11.5 billion cubic feet in the early 1960's to nearly 14 billion cubic feet—up some 22 percent.

(1) Projections show demands for forest and range products rising faster than supplies.

Projections of demand for forest, range, and inland water products, based on assumed increases in population, economic activity, income, prices, and the other determinants used in this study, show continued growth through the projection period. However, as indicated by the illustrative projections shown in the tabulation below, there are differences in the amount of increase.

Product	*Base Year*	*Projected increase in demand (medium level—base year equals 100)*		
		1980	*2000*	*2020*
Remote camping	1975	106	133	180
Birdwatching	1975	107	138	168
Small game hunting	1975	106	121	136
Freshwater fishing	1975	111	156	205
Forest-range grazing	1970	135	150	164
Timber	1970	131	173	219
Water (consumptive use)	1975	103	123	139

Although there are differences in projected growth in demand, the increases for all products are substantially above the levels that can be supplied with present management programs and existing facilities. This means that the Nation is faced with the prospect of rising costs for products such as timber, forage, and water and intensifying competition for the available supplies of wildlife, fish, and outdoor recreation.

(2) The Nation has a huge forest and range land base

This outlook is not inevitable. For example, there is a huge land and water base which can be used to meet demands. In 1970, 1.6 billion acres, some 69 percent of the Nation's area, were classified as forest and range land and inland water. About two-thirds of this area was in range land and noncommercial forest. These lands, chiefly used for grazing, include natural grasslands, savannas, shrublands, most deserts, tundra, coastal marshes, wet meadows, and forested land such as the pinyon-juniper forests of the Southwest that is incapable of producing crops of industrial wood. Another 500 million acres were commercial timberland, i.e., land that is capable of producing in excess of 20 cubic feet of industrial wood per acre a year in natural stands and not withdrawn for other uses. The remaining area—some 48 million acres—was classified as inland water and consisted of lakes, reservoirs, and ponds over 40 acres in size (exclusive of the Great Lakes) and streams more than one-eighth mile in width.

About a third of the rangeland and noncommercial forest, some 345 million acres, is in Alaska. Most of the remainder is in the States stretching westward from the Great Plains to the Pacific Coast.

Commercial timberlands are more widely distributed and with the exception of the Great Plains and some of the Southwest compose a significant part of the area of each State. However, nearly three-quarters of the area is in the humid eastern half of the country where it is about equally divided between the North and South. The one-quarter of the commercial timberland in the West is concentrated in the Pacific Coast States of Oregon, Washington, and California; and the Rocky Mountain States of Montana, Idaho, and Colorado.

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As a result of the large area and wide geographic distribution, the Nation's forest and range lands have a diversified vegetative cover ranging from moss, lichens, and short grasses, through tall grasses and shrubs, to the huge trees of the Pacific Coast such as redwood and Douglas-fir.

(3) The bulk of the forest and range land is privately owned

The great bulk of the Nation's forest and range land in the contiguous States is in private ownerships. In 1970, the area in these ownerships, plus relatively small areas in State, county, and municipal ownerships amounted to 825 million acres—about 70 percent of the forest and range land area.

Rangeland on which the grass form predominates is even more heavily concentrated in these ownerships. For example, in 1970, some 99 percent of the prairie grasslands, 94 percent of the plains grasslands and 84 percent of the mountain grasslands was in non-Federal ownership, nearly all private.

In contrast, Federal ownership predominated on most of the rangeland shrub ecosystems. Some 82 percent of the sagebrush system and 70 percent of desert shrub was in Federal holdings. Federal ownership was also the dominant form on the noncommercial forest ecosystems—chaparral-mountain shrub and pinyon-juniper—in the contiguous States. It was also the dominant form in Alaska where in 1970 nearly all of the rangeland and noncommercial forest was Federally owned.

Some 364 million acres, 73 percent of the Nation's commercial timberland, is in private ownerships. Much of this area is in highly productive sites and close to markets for timber products. These ownerships consequently have long been of major importance as a source of timber supplies for the wood-using industries. Nearly half of these timberlands are in the South and most of the remainder in the North.

The 136 million acres of commercial timberland in public ownership, largely Federal, are concentrated in the Rocky Mountains and Pacific Coast sections. Most are of relatively low site quality and located at higher elevations, but these forests nevertheless contain a substantial part of the Nation's timber inventory.

(4) Productivity of forest and range land generally low

The productivity of the Nation's forest and range lands varies widely as a result of differences in climate, soils, and elevation. In general, however, productivity is relatively low. For example, it is estimated that about a quarter of the rangeland areas in the contiguous States is in the lowest productivity class with another three-fifths in the moderately low class. A large proportion of the lands in these lower classes is in National Forest and other Federal ownership. Only 4 percent of the area was estimated to be in the high productivity class.

Nearly three-quarters of the rangeland was producing less than 60 percent of its potential in 1970. The largest proportion of lands in good condition was in the plains and prairie grasslands ecosystems.

More than a quarter of the commercial timberland is in the lowest site productivity class, i.e., land capable of producing 20 to 50 cubic feet of timber per acre per year in fully stocked natural stands. This class of land provides limited response to timber management activities but often yields important values for grazing, recreation, or other nontimber uses. These lower site lands are mostly in eastern areas such as the Appalachians, and in the Rocky Mountains where this site class makes up about half of the commercial area.

Nearly two-thirds of the total area of commercial timberland is in the 50 to 120 cubic foot productivity range. About half of this acreage is in the South.

The remaining 10 percent of the commercial area is in the highest productivity class—lands capable of producing 120 cubic feet or more of timber per acre per year. Nearly half of this highly productive land is in the Pacific Coast section, largely supporting Douglas-fir, hemlock-sitka spruce, and western hardwoods.

The potential yields indicated by site productivity classifications are generally not realized, even though practically all commercial timberland in 1970 was occupied to some extent by some type of tree cover, and many forests were fully stocked or even overstocked in terms of all live trees.

(5) The Nation's forest and range lands have the capacity to produce much larger volumes of nearly all forest and range products

In time, and with additional investments in management programs and physical facilities, the output of nearly all forest, range, and inland water products can be greatly increased and the higher levels of output sustained in the future.

For example, the 1.6 billion acres of forest and range land, and the associated inland water, have the physical capacity to supply sites for picnicking, camping, hiking, skiing, birdwatching, swimming, and most other types of outdoor recreation that is far in excess of projected increases in demand. These lands, under proper management, also have the capacity to support much larger numbers of most species of wildlife, including those species in demand by hunters and fishermen, and noncon-

sumptive users such as birdwatchers and photographers. Forage production from range can be nearly tripled and timber growth on commercial timberland more than doubled. Water supplies in deficit areas can also be substantially increased.

In addition to increasing supplies, it is possible to greatly extend the usable supplies of most forest and range products by improvements in the efficiency of utilization.

The most promising opportunities to increase and extend supplies include:

Outdoor recreation.—Projected increases in demands for nearly all types of outdoor recreation can be met by:

- Constructing additional facilities such as roads, trails, campgrounds, picnic areas, and boat ramps.
- Spreading use to little used or underused areas.
- Improving public access to forest and range land suitable for outdoor recreation, especially near urban areas where nearly all land is privately owned.
- Integrating all outdoor recreation uses including scenic values into land use planning and management.
- Improving maintenance of existing facilities and providing for adequate pollution abatement.

Wilderness.—The supply of Wilderness can be increased by:

- Setting aside additional forest and range land areas as Wilderness.

Part of the prospective growth in demand for the use of Wilderness for outdoor recreation can be met by:

- Developing means to spread geographically and through time recreation use on established Wildernesses.
- Spreading use to non-Wilderness lands such as backcountry areas where experiences similar to those in Wilderness are realizable.

Wildlife.—The present wildlife and fish situation can be improved:

- Populations of most wildlife species can be increased by expanding food supplies, improving cover, and minimizing the adverse impacts from the use of the land and water base for other purposes. At this time, much can be accomplished by effectively integrating wildlife needs into the management of the resource base for other products such as forage and timber.
- Waterfowl populations can be increased by expanding wetlands nesting habitats through fee purchase of key tracts and wetlands easements in the United States and Canada, and preserving and enhancing migration and wintering habitats.
- Fish populations can be increased by additional stocking of desirable species and improving habitat, and especially water quality through control of various types of pollution and removing obstacles to migration by eliminating barriers and providing ladders or other passageways in water resource projects.
- Part of the prospective increases in demand for wildlife, for both consumptive and nonconsumptive uses, can be met by providing access through the construction of trails, boat landings, and other facilities to places where the existing resource is underutilized, and spreading use through time and in developed areas where the wildlife resource can support additional use.
- Endangered and threatened species require special measures. For some species, notably those most restricted and isolated, habitat must be preserved and protected from further encroachment. It may be possible to increase the populations of some species by transplanting them to unoccupied or newly developed habitat.

Forest-range forage.—The supply of forest-range forage can be increased and extended by:

- Obtaining better and more uniform utilization of existing forage by implementation of improved grazing systems, including better livestock distribution, building needed fences, developing needed sources of water, and using the proper kind and class of livestock for the range.
- Improving the growth and quality of forage by seeding of improved native and introduced forage species, control of undesirable plants, converting marginal forest or undesirable shrub stands to grasslands, use of managed fire, fertilization, and waterspreading and pitting.
- Coordinating forest-range management activities with other resource uses.
- Reducing loss of livestock and forest-range forage by improved control of wildfire, damaging range insects and diseases, predators, and livestock diseases and parasites.

Timber.—Timber supplies can be increased and extended by:

- More intensive management of all classes of commercial timberland by such measures as timber stand improvement; commercial thinning and salvage; reforestation; better protection against fire, insects, diseases, and other destructive agents; road construction, fertilization; and the use of genetically improved planting stock. More complete utilization of logging residues, plant residues, and trees lost by mortality; and greater use of recycled fibers.
- Greater use of modern equipment and new technology to increase output of lumber and other products from available log supplies and raise the efficiency with which products are used in construction and manufacturing.

Water—Water supplies can be increased in a given area by interregional or interbasin transfer, desalting, and precipitation modification.

Water supplies can be extended by:

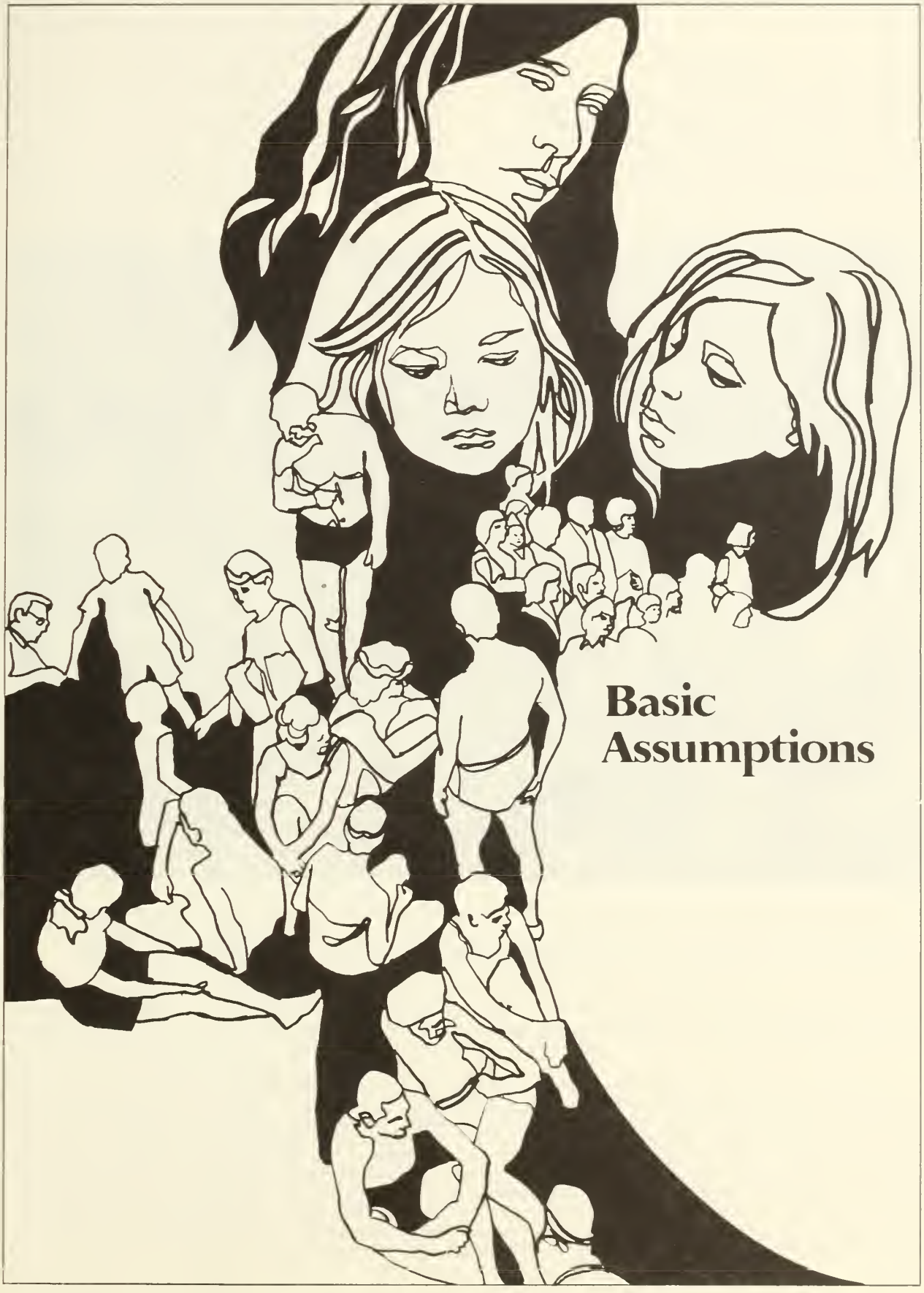
- More intensive watershed protection and management of forest and range lands to enhance the natural recharge of ground water and improve timing of flows by storage and/or vegetation modification.
- Improving the efficiency of irrigation systems by reducing transmission losses, phreatophyte management, and more efficient application methods.
- Improving the efficiency of central supply systems by elimination of leaks in transmission systems, use of water meters with charges according to use and implementation of water saving technology such as more efficient plumbing fixtures and appliances.
- Pricing to encourage more efficient use of water.

General opportunities to increase and extend supplies.—Most of the Nation's forest and range land, and inland water, is in private ownership. A variety of studies has shown that these owners have diverse objectives, widely different characteristics and attitudes, a limited knowledge of existing management opportunities and varying willingness and capacity to make investments which will increase and extend supplies of forest and range products.

Substantial increases in the supplies of most forest, range, and inland water products from these ownerships can be achieved by such measures as cost sharing programs to help finance management practices and technical assistances and educational programs to show landowners how to develop and manage forest, range and inland water resources.

Much can be done to increase and extend supplies of forest, range, and inland water products by better use of existing technology. But investments in management practices and facilities could be made more efficient by expanding research. More information is needed, for example, about physical responses in terms of changes in wildlife populations and in forage and timber growth to various kinds of management practices. More data is also needed on the cost of management practices, the prices and uses of forest and range products, and the physical aspects of the forest and range resource. Research on ways of using forest and range land, and inland water, which will minimize impacts on the environment is becoming increasingly urgent.

As described above, there are many opportunities to greatly increase and extend supplies of forest and range products. But inevitably, the point will be reached where increasing the output of one product will constrain or reduce the output of another. Research is perhaps the best hope of developing ways of integrating and balancing multiple uses and reducing the conflicts which are likely to result from rapidly expanding demands.



Basic Assumptions

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Population, an indicator of demand for many renewable resource products, is likely to grow fairly rapidly in the decades immediately ahead.

This chapter presents the general basic assumptions used in making demand and supply projections for outdoor recreation and wilderness, wildlife and fish, forest-range grazing, timber, and water which are presented below. In partial recognition of the uncertainty about future changes, three alternative assumptions are presented for population, economic activity, and income. The alternatives cover the range over which growth in these major determinants could reasonably be expected to vary.

In making these assumptions, it is recognized that the outlook during the next few decades is much more uncertain than it seemed a few years ago. The longrun effects of large increases in the price of fossil fuels and other raw materials, worldwide inflation and recession, and the unchecked growth in population and famine in many regions of the world are still unclear. However, it seems reasonable to expect that many of today's problems will be resolved, and that population, economic activity, and income in the United States and most other countries in the world will continue to grow during the period covered in this study.

Population

Changes in population have an important effect on the demand for timber, forage, water, and the other forest, range, and inland water products. They also influence the size of the labor force, a major determinant of the level of economic activity and related materials usage and disposable income.

In the five decades between the early 1920's and the early 1970's, the population of the United States increased by about 100 million people, rising at an average annual rate of 1.3 percent (table 1, fig. 1). The most recent projections of the Bureau of the Census[1] indicate that population is likely to continue

[1] U.S. Department of Commerce, Bureau of the Census. Projections of the population of the United States, by age and sex, 1975–2000 with extensions of total population to 2025. Cur. Pop. Reps. Ser. P–25, No. 541, 6 p. 1975.

Table 1. *Measures of population and economic growth, selected years 1920–74, with projections to 2020*

Year	Population		Gross national product[1]		Per capita gross national product		Disposable personal income[1]		Per capita disposable personal income	
	Millions	*Annual rate of increase*	*Billions of 1967 dollars*	*Annual rate of increase*	*1967 dollars*	*Annual rate of increase*	*Billions of 1967 dollars*	*Annual rate of increase*	*1967 dollars*	*Annual rate of increase*
1920	106.5	—	160.5	—	1,507	—	—	—	—	—
1925	115.8	1.7	201.8	4.7	1,743	3.0	—	—	—	—
1930	123.2	1.2	215.8	1.4	1,752	0.1	159.1	—	1,391	—
1935	127.4	0.7	199.3	−1.6	1,564	−2.2	150.8	−1.1	1,184	−3.2
1940	132.6	.8	267.1	6.0	2,014	5.2	190.3	4.8	1,435	3.9
1945	140.5	1.2	417.6	9.4	2,972	8.1	262.8	6.7	1,870	5.4
1950	152.3	1.6	417.8	0.1	2,743	−1.6	285.6	1.7	1,875	0.1
1955	165.9	1.7	515.0	4.3	3,104	2.5	339.4	3.5	2,046	1.8
1960	180.7	1.7	573.4	2.2	3,173	.4	389.2	2.8	2,154	1.0
1965	194.3	1.5	726.4	4.8	3,739	3.3	497.7	5.0	2,562	3.5
1966	196.6	1.2	773.8	6.5	3,936	5.3	525.0	5.5	2,670	4.2
1967	198.7	1.1	793.9	2.6	3,995	1.5	546.3	4.7	2,749	3.0
1968	200.7	1.0	830.8	4.6	4,140	3.6	570.8	4.5	2,844	3.5
1969	202.7	1.0	853.2	2.7	4,209	1.7	587.6	2.9	2,899	1.9
1970	204.9	1.1	849.5	− .4	4,146	−1.5	611.8	4.1	2,986	3.0

[1] The 1970 trend level for the gross national product ($882 billion) and disposable personal income ($610 billion) were used as the base for calculating the projected values.

Note: Annual rates of increase are calculated for 5-year periods from 1920 through 1965, for 1-year periods 1966 through 1974, and for 10-year periods 1970 through 2020.

Sources: Population, U.S. Department of Commerce, Bureau of the Census. 1920–45—*Population estimates and projections*. Cur. Pop. Reps. Ser. P–25, No. 442, 1970; 1950–70—*Estimates of the population of the United States to December 1, 1971*. Cur. Pop. Reps. Ser. P–25, No. 474. 1972; 1971–74—*Estimates of the population of the United States to February 1, 1975*. Cur. Pop Reps. Ser. P–25, No. 543, 1975. 1980–2000—*Projections of the population of the United States, by age and sex, 1975 to 2000 with extensions of total population to 2025*. Cur. Pop. Reps. Ser. P–25, No. 541, 1975.

Gross national product and per capita gross national product derived from data published in the following sources: 1920–25—U.S. Congress, Joint Committee on the Economic Report. *Potential economic growth of the United States during the next decade*. 83rd Cong., 2nd sess. 1954; 1930–74—Council of Economic Advisers. *Economic report of the President*. February 1975. Medium projections of rates of growth to 1980 based on data published by the U.S. Department of Labor, Bureau of Labor Statistics. *The U.S. economy to 1985, a summary of BLS projections*. Bull. 1809, 1974; Executive Office of the President, Office of Management and Budget. *The budget of the United States Government fiscal year 1976*. 1975; and U.S. Water Resources Council. *1972 OBERS projections regional economic activity in the United States Vol. 1. Concepts, methodology and summary data*. 1974. Medium projections of rates of growth beyond 1980 based on data published by the Water Resources Council, *ibid*. High and low projections of rates of growth Forest Service assumptions.

Disposable personal income and per capita disposable personal income derived from data published in the following source: 1930–74—Council of Economic Advisers. *Economic report of the President*. February 1975. Projections: Forest Service estimates.

Table 1 (*Continued*)

Year	Population		Gross national product[1]		Per capita gross national product		Disposable personal income[1]		Per capita disposable personal income	
	Millions	*Annual rate of increase*	*Billions of 1967 dollars*	*Annual rate of increase*	*1967 dollars*	*Annual rate of increase*	*Billions of 1967 dollars*	*Annual rate of increase*	*1967 dollars*	*Annual rate of increase*
1971	207.0	1.0	877.5	3.3	4,239	2.2	635.4	3.9	3,070	2.8
1972	208.8	.9	931.8	6.2	4,463	5.3	664.1	4.5	3,181	3.6
1973	210.4	.8	986.7	5.9	4,690	5.1	708.8	6.7	3,369	5.9
1974	211.9	.7	965.4	−2.2	4,556	−2.9	690.1	−2.6	3,257	−3.3
					Low Projections					
1980	220	0.7	1,240	3.5	5,640	2.7	870	3.6	3,950	2.8
1990	236	.7	1,670	3.0	7,080	2.3	1,170	3.0	4,960	2.3
2000	245	.4	2,250	3.0	9,180	2.6	1,570	3.0	6,410	2.6
2010	250	.2	2,890	2.5	11,560	2.3	2,020	2.5	8,080	2.3
2020	252	.1	3,510	2.0	13,930	1.9	2,460	2.0	9,760	1.9
					Medium Projections					
1980	223	0.9	1,310	4.0	5,870	3.1	910	4.1	4,080	3.2
1990	245	.9	1,840	3.5	7,510	2.5	1,290	3.6	5,270	2.6
2000	262	.7	2,600	3.5	9,920	2.8	1,820	3.5	6,950	2.8
2010	279	.6	3,490	3.0	12,510	2.4	2,440	3.0	8,750	2.3
2020	294	.5	4,470	2.5	15,200	2.0	3,130	2.5	10,650	2.0
					High Projections					
1980	226	1.0	1,370	4.5	6,060	3.5	960	4.6	4,250	3.6
1990	258	1.3	2,030	4.0	7,870	2.6	1,420	4.0	5,500	2.6
2000	287	1.1	3,000	4.0	10,450	2.8	2,100	4.0	7,320	2.9
2010	322	1.2	4,230	3.5	13,140	2.3	2,960	3.5	9,190	2.3
2020	362	1.2	5,690	3.0	15,720	1.8	3,980	3.0	10,990	1.8

Population 1920 - 74,
with projections to 2020

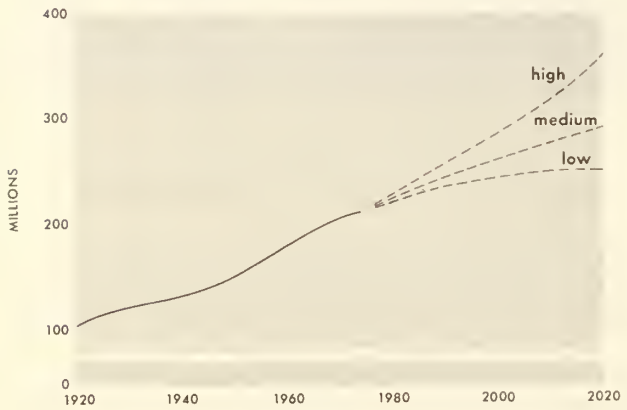


Figure 1

to grow fairly rapidly through the projection period. The Census Series II projection—the medium projection of this study—shows population rising by another 82 million by 2020. In line with recent trends, however, the annual rate of growth declines from about 1 percent in the late 1960's and early 1970's to 0.5 percent in the decade 2010–2019. Although there is a substantial increase in numbers under the low assumption, nearly all of this occurs prior to 2010. Population growth under this assumption is very slow in the 2010–19 decade and declines in the first half of the next decade.

The decline in the rate of population growth reflects Bureau of the Census assumptions about fertility rates.[2] There have been large fluctuations in fertility rates in recent decades, as illustrated in figure 2, but since the late 1950's, the trend has fallen sharply. The medium projection is based on an as-

[2] Fertility rates indicate the number of births per 1,000 women during their child bearing years. For a more detailed technical definition, see U.S. Department of Health, Education, and Welfare; Public Health Service. Natality Statistics Analysis United States, 1965–67. National Center for Health Statistics, Ser. 21, No. 19, 39 p. 1970.

Total fertility rates 1920 - 73, with projections to 2020

Figure 2

Gross national product 1920 - 74, with projections to 2020

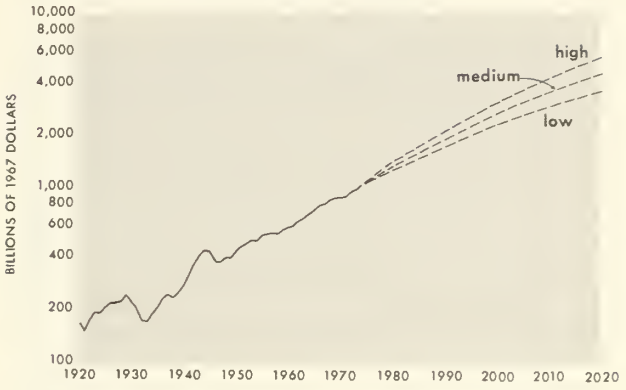


Figure 3

sumed fertility rate of 2.1—a level close to current birth expectations of young American wives.[3] The current fertility rate is below this figure and approximates a level which would result in population stabilization in the first part of the twenty-first century.

Immigration accounts for a significant part of population growth, and the estimates shown in table 1 include a net addition of 400,000 immigrants each year. There has been some decline in immigration recently. Future reductions could result from mounting national concern about unemployment and population pressure on resources and the environment.

The age distribution of the population is important in estimating demands for recreation and housing—an important determinant of the demand for timber products. The Bureau of the Census projections of age classes associated with the population projections shown in table 1 have been used in this study. These projections indicate a substantial increase in the number and proportion of people in the middle age classes—the classes that have the highest income levels and the largest demands for goods and services.

Gross National Product

In recent decades, changes in the consumption of water and many timber products have been closely associated with changes in the Nation's gross national product, i.e., the value of all goods and services produced in the economy.

Between 1920 and 1970, the gross national product, measured in constant 1967 dollars, increased more than 5 times—rising at an average annual rate of 3.4 percent (table 1, fig. 3). Annual changes have fluctuated widely, from as much as +16.1 percent to −14.8 percent (fig. 4). The highest sustained rates of growth in gross national product occurred in the 1960's, when they averaged 4.0 percent per year.

The wide fluctuations in annual rates of growth in the gross national product have reflected such factors as differences in the rates of change in labor force, rates of unemployment, hours worked per year, and productivity. These factors will presumably continue to cause fluctuations in gross national product in the years ahead. But for this study, only trends in growth were considered, and projections were based on the following assumed rates of increase:

	Annual rates of growth (percent)		
Decade	*Low*	*Medium*	*High*
1970–79	3.5	4.0	4.5
1980–89	3.0	3.5	4.0
1990–99	3.0	3.5	4.0
2000–09	2.5	3.0	3.5
2010–19	2.0	2.5	3.0

The rate used as the medium projection for the 1970's is the same as that projected by the U.S. De-

Annual percentage change in gross national product 1920 - 74

Figure 4

[3] U.S. Department of Commerce, Bureau of the Census. Fertility expectations of American women: June 1974. Cur. Pop. Rpt. Ser. P-25, No. 277, 56 p. 1975.

partment of Labor[4] and the Water Resources Council[5] and consistent with projections for the last half of the 1970's published by the Executive Office of the President.[6] The assumed medium rates for the decades beyond the 1970's are based upon projections of the Water Resources Council.[5] The high and low rates are Forest Service assumptions that are intended to include a range over which rates of growth could reasonably be expected to vary.[7]

The medium assumed rate of growth would result in a gross national product of $2,600 billion (1967 dollars) in 2000—some 2.7 times that of 1974 (table 1). By 2020, this projection would reach $4,470 billion—some 4.6 times that of 1974. The associated projection of per capita gross national product in 2020 rises to 15,200—3.3 times the 1974 average.

These projections rest on the assumption that the U.S. economy will continue to produce large quantities of physical goods, and that adequate supplies of raw materials and energy will be available to support sustained growth over the projection period.

Both of these assumptions are being increasingly challenged, and for the long run, it is difficult to conceive of an indefinite continuation of high geometric growth rates. Also, concern over the environment could affect the types of goods produced, man-hour productivity, and the rate of increase in gross national product. However, the economic growth assumptions adopted should provide an acceptable basis for evaluating the potential demands for forest, range, and inland water products and guiding management policies and programs during the next few years. After that time, and as required by the Forest and Rangeland Renewable Resources Planning Act, the outlook will be reevaluated and new expectations on economic growth incorporated in the next (1979) Renewable Resource Assessment.

[4] U.S. Department of Labor, Bureau of Labor Statistics. The U.S. economy to 1985, a summary of LBS projections. Bull. 1809. 1974.

[5] U.S. Water Resources Council. 1972 OBERS projections regional economic activity in the United States. Vol. 1. Concepts, methodology and summary data. 164 p. 1974.

[6] Executive Office of the President, Office of Management and Budget. The budget of the United States Government fiscal year 1976. 384 p. 1975.

[7] The assumed low and high rates of growth in gross national product rest on an implicit assumption that the proportion of the population in the labor force, and of the Nation's product available for capital formation, would not vary with population levels. This is a simplifying assumption that is unlikely to be realized because labor force participation and capital formation rates would logically vary inversely with the rate of population growth. If this were taken into account, the gross national product and disposable personal income estimates associated with the "low" level population projection would be increased and those with the "high" projection decreased.

Disposable Personal Income

Disposable personal income, i.e., the income available for spending or saving by the Nation's population has been another important determinant of the demand for certain products, such as many types of recreation and various grades of paper and board. It also influences household formation, size of dwellings, and furniture consumption—all important determinants of the demand for lumber and other timber products.

Since 1929, disposable personal income has equaled about 70 percent of the gross national product. This historical and rather constant relationship was assumed to continue through the projection period (table 1).

The resulting estimates (medium level) show per capita disposable personal income more than tripling by 2020 in constant 1967 dollars. This means, of course, that the Nation is faced not only with the task of meeting the resource demands of an additional 82 million people, but the demands of 294 million people with much greater purchasing power than today's population.

Institutional and Technological Changes

Institutional and technological changes in the U.S. economy have substantially influenced use of renewable resources. Increasing urbanization, for example, has led to increased demand for some types of outdoor recreation and been an important source of the intensifying concern about the environment. It has also caused important shifts in the use of raw materials including the partial displacement of timber products by steel, concrete, and other materials suitable for use in large urban structures.

Technological changes have also affected the demand for some resources. For example, recent developments in the pulp industry have substantially reduced the amount of water required to produce a ton of wood pulp. Innovations in the metals and plastics industries have resulted in displacement of lumber and plywood in products such as furniture and containers. On the other hand, new technology has simultaneously led to large increases in the use of lumber in pallets, greater use of plywood in construction, and use of pulp and paper, plywood, hardboard, and particleboard in a wide assortment of end uses.

The use of historical data as a base for projections implicitly assumes a continuing stream of technological and institutional changes such as have occurred in the past, as well as the continuation of recent trends in other variables such as educational levels, tastes, capital availability, and military activities. Projections of demands for products have also been

adjusted for specific technological and institutional changes that appear likely.

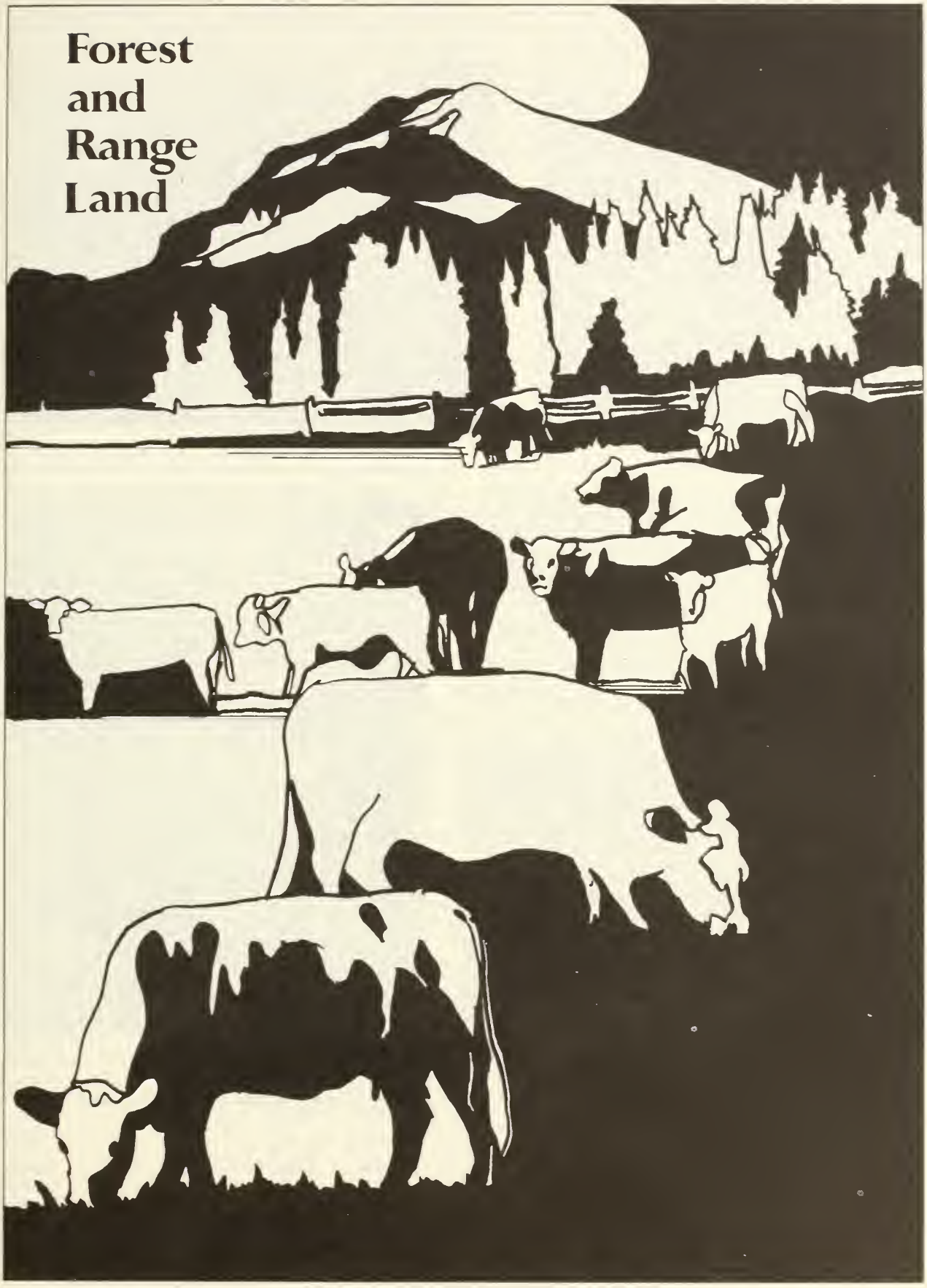
Energy Costs

The recent and large increases in energy costs, and the prospects for continuing limitations on supplies, has created great concern about prospective impacts on economic growth and the demand for various forest and range land products such as water, timber, grazing, and outdoor recreation. At this time, there are no authoritative and generally accepted estimates of the size of future relative price increases for energy materials. It does appear, however, that a substantial and persistent upward shift is likely. This has been taken into account on a judgmental basis in preparing projections of demands and supplies for those products where the higher prices are likely to have a significant impact.

Other Assumptions

In addition to the general assumptions outlined above, the projections of demands and supplies for the products included in this study rest on a variety of other specified and implied assumptions. The most important, such as those on prices, changes in commercial timberland and rangeland areas, management intensities, the continuation of past relationships between variables, and constraints on the supplies of renewable resources associated with multiple use management and protection of the forest and range environment have been described in the appropriate places in the chapters that follow.

Forest and Range Land



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Nearly 70 percent (1.6 billion acres) of the Nation's area is classified as forest and range land and inland water.

This chapter contains information on the (1) area and location of the Nation's forest and range lands and associated inland waters and (2) ownership, characteristics, and major uses of the forest and range areas.

Forest and Range Land Areas

In 1970, 1.6 billion acres, some 69 percent of the Nation's area was classified as forest and range land and inland water (table 2). The remaining area was cropland, improved pasture, and other lands; i.e., deserts, barrens, and land used as residential and industrial sites, roads, airports, and for a variety of other purposes.

About 1.1 billion acres—two-thirds of the forest, range, and inland water area—was classified as rangeland and noncommercial forest. The rangeland includes natural grasslands, savannas, shrublands, most deserts, tundra, coastal marshes, and wet meadows. The noncommercial forest includes ecosystems such as pinyon-juniper or high subalpine forests that are incapable of producing crops of industrial wood because of poor site or other adverse conditions, and productive forested land withdrawn for parks, wildlife refuges, recreation areas or other uses not compatible with timber production. Another 500 million acres were classified as commercial timberland, i.e., land capable of producing more than 20 cubic feet of industrial wood a year in natural stands and not withdrawn for other uses. The remaining area—some 48 million acres—was classified as inland water and consisted of lakes, reservoirs, and ponds over 40 acres in size (exclusive of the Great Lakes) and streams more than 1/8 mile in width. Smaller lakes and streams are included in the land statistics. These smaller bodies of water are of great importance in providing habitat for fish and wildlife and many forms of outdoor recreation.

Geographic Distribution of Forest and Range Lands

The rangeland and noncommercial forest are concentrated in the Western States and Alaska (fig. 5). About two-fifths of this land is in Texas and New Mexico and the States stretching northward through Montana and North Dakota. Another third, some 345 million acres, is in Alaska. Most of the remaining area is in the Southwestern States.

Commercial timberlands are more widely distributed and, with the exception of the Great Plains region, Alaska, and some of the Southwest, compose a significant part of the land area of each State (fig. 6). Nearly three-quarters of the area is in the humid eastern half of the country. Some of the States in this part of the country are heavily forested. For example, commercial timberlands cover over 80 percent of the total land area in New England and more than half of the area along the Atlantic Coast.

The one-quarter of the commercial timberland in the West is concentrated in the Pacific Coast States

Table 2. *Land and inland water areas of the United States, by major class of land and State, January 1970*[1]

(*Million acres*)

State	Total land and inland water area	Land							Inland water area
		Total land area	Forest and range land[2]			Cropland	Privately owned improved pasture	Other land	
			Total	Commercial timberland	Rangeland and noncommercial forest				
Alabama	33.0	32.5	21.8	21.7	0.1	5.1	3.6	2.0	0.5
Alaska	375.3	362.5	351.2	5.6	[3] 345.6	([4])	0.1	11.3	12.8
Arizona	72.9	72.7	63.2	3.7	59.5	1.4	.3	7.8	.2
Arkansas	34.0	33.4	18.7	18.2	.5	8.5	3.3	2.8	.6
California	101.6	100.2	66.7	16.8	49.9	11.8	1.8	19.9	1.4
Colorado	66.7	66.4	51.0	11.6	39.4	9.6	3.1	2.7	.3
Connecticut	3.2	3.1	2.0	2.0	([4])	0.2	.2	0.7	.1
Delaware	1.3	1.3	.4	.4	([4])	.5	.1	.2	.1
Florida	37.5	34.6	19.5	16.2	3.3	3.7	2.7	8.8	2.8
Georgia	37.7	37.2	27.5	25.1	2.4	6.4	2.8	.6	.4
Hawaii	4.1	4.1	2.9	1.1	1.8	.4	.5	0.3	([4])
Idaho	53.5	52.9	42.3	15.2	27.1	5.2	2.2	3.2	.6
Illinois	36.1	35.8	3.8	3.7	.1	23.9	3.6	4.5	.3
Indiana	23.2	23.2	3.9	3.8	.1	13.3	2.8	3.2	.1
Iowa	36.0	35.9	2.5	2.4	.1	26.4	4.2	2.7	.2

See footnotes at end of table.

Table 2 (*Continued*)

State	Total land and inland water area	Land							Inland water area
		Total land area	Forest and range land[2]			Cropland	Privately owned improved pasture	Other land	
			Total	Commercial timberland	Rangeland and non-commercial forest				
Kansas	52.6	52.5	15.7	1.2	14.5	29.4	1.7	5.7	.1
Kentucky	25.9	25.5	11.8	11.8	(4)	8.7	4.1	1.0	.3
Louisiana	31.1	28.9	15.8	15.3	.5	5.6	1.8	5.7	2.2
Maine	21.3	19.8	17.3	16.9	.4	.9	.3	1.3	1.5
Maryland	6.8	6.3	3.0	2.9	.1	1.8	.6	1.0	.4
Massachusetts	5.3	5.0	3.5	3.5	(4)	.2	.3	1.0	.3
Michigan	37.3	36.4	19.5	18.8	.7	9.5	1.6	5.8	.9
Minnesota	53.8	50.7	19.1	16.9	2.2	22.2	3.5	5.9	3.1
Mississippi	30.5	30.3	17.0	16.9	.1	6.6	4.0	2.7	.2
Missouri	44.6	44.2	15.0	14.6	.4	18.0	8.1	3.1	.4
Montana	94.2	93.2	75.5	16.0	59.5	14.4	2.9	.4	1.0
Nebraska	49.4	49.0	25.0	1.0	24.0	22.1	1.6	.2	.5
Nevada	70.7	70.3	64.0	.1	63.9	.6	.8	4.9	.4
New Hampshire	6.0	5.8	5.1	5.0	.1	.2	.1	.4	.2
New Jersey	5.0	4.8	2.4	2.4	(4)	.7	.3	1.4	.2
New Mexico	77.9	77.7	71.4	5.7	65.7	1.9	.7	3.8	.1
New York	31.7	30.6	17.0	14.5	2.5	5.8	3.1	4.7	1.1
N. Carolina	33.7	31.3	20.7	20.2	.5	5.3	2.5	2.8	2.4
N. Dakota	45.2	44.3	12.5	.4	12.1	27.4	2.0	2.4	.9
Ohio	26.4	26.3	6.4	6.4	(4)	11.5	3.3	4.9	.1
Oklahoma	44.7	44.1	22.0	4.8	17.2	13.0	4.8	4.3	.6
Oregon	62.1	61.6	53.6	25.7	27.9	5.3	.8	1.9	.5
Pennsylvania	29.0	28.8	17.5	17.5	(4)	5.6	3.3	2.4	.2
Rhode Island	.8	.7	.4	.4	(4)	(4)	.1	.2	.1
S. Carolina	19.9	19.4	12.6	12.4	.2	4.0	.7	2.1	.5
S. Dakota	49.3	48.6	25.9	1.5	24.4	18.7	1.6	2.4	.7
Tennessee	27.0	26.5	13.6	12.8	.8	7.9	3.5	1.5	.6
Texas	171.1	168.3	112.7	12.9	99.8	34.3	15.7	5.6	2.8
Utah	54.3	52.7	45.2	3.8	41.4	1.6	1.0	4.9	1.6
Vermont	6.1	5.9	4.4	4.4	(4)	.8	.5	.2	.2
Virginia	26.1	25.5	16.6	15.9	.7	3.4	4.1	1.4	.6
Washington	43.6	42.7	31.4	18.4	13.0	8.1	.7	2.4	1.0
W. Virginia	15.5	15.4	12.1	12.1	(4)	.9	2.2	.2	.1
Wisconsin	35.9	34.9	15.2	14.5	.7	12.0	3.2	4.5	1.1
Wyoming	62.7	62.3	57.4	4.2	53.2	2.2	1.0	1.7	.4
All States	2,313.7	2,266.2	1,555.7	499.3	1,056.4	427.0	117.8	165.5	47.5

[1] Columns may not add to totals because of rounding.

[2] Forest land is defined as land at least 10 percent occupied by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use.

Commercial timberland is defined as forest land producing or capable of producing crops of industrial wood in excess of 20 cubic feet per acre per year in natural stands and not withdrawn from timber utilization.

Noncommercial forest land is unproductive forest land incapable of producing more than 20 cubic feet of industrial wood per acre per year because of adverse site conditions and productive forest land reserved for parks, wilderness, or other nontimber uses.

Rangeland is land on which the native vegetation (climax or natural potential) is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing and present in sufficient quantity to justify grazing or browsing use. Rangelands include natural grasslands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows.

[3] Includes 12.6 million acres of forest land in interior Alaska which has a growth potential in excess of 20 cubic feet per year, the minimum standard for commercial timberland. This has been excluded from the commercial category because of geographic remoteness and potentially high development costs.

[4] Less than 50,000 acres.

U.S. Department of Commerce, Bureau of the Census. *Area measurement reports*, GE–20 No. 1, 22 p. 1970; *1964 Census of Agriculture;* U.S. Department of Agriculture, Forest Service. *The Nation's range resources—a forest-range environmental study*. Forest Resource Rep. 19, 147 p. 1972; *The outlook for timber in the United States*. Forest Resource Rep. 20. 367 p. 1973; U.S. Department of Agriculture, Forest Service. Estimates based on information published by the Joint Federal-State Land Use Planning Commission for Alaska, *Major ecosystems of Alaska*. (map), 1973; and U.S. Department of the Interior. Alaska (map). 1974.

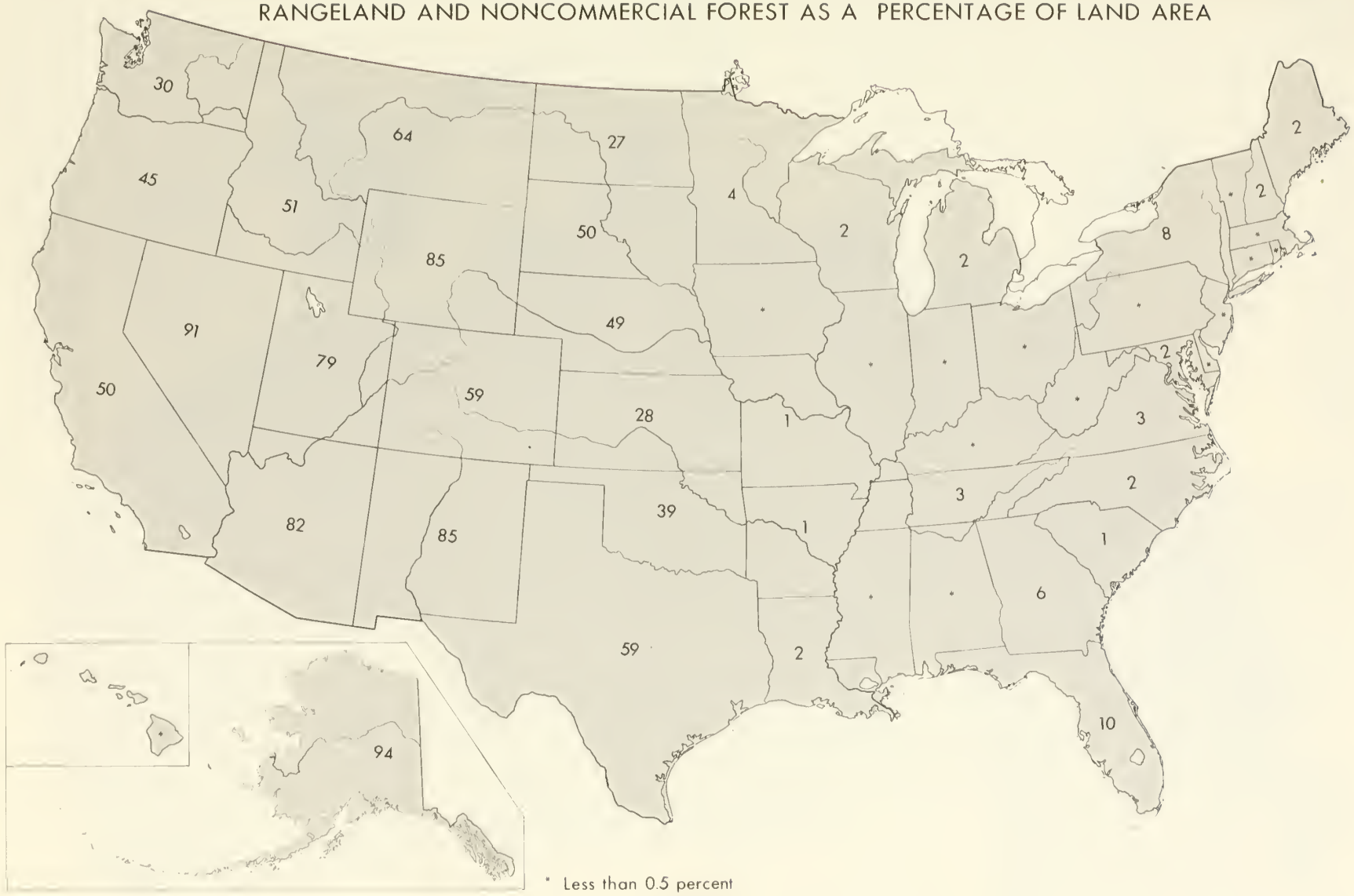
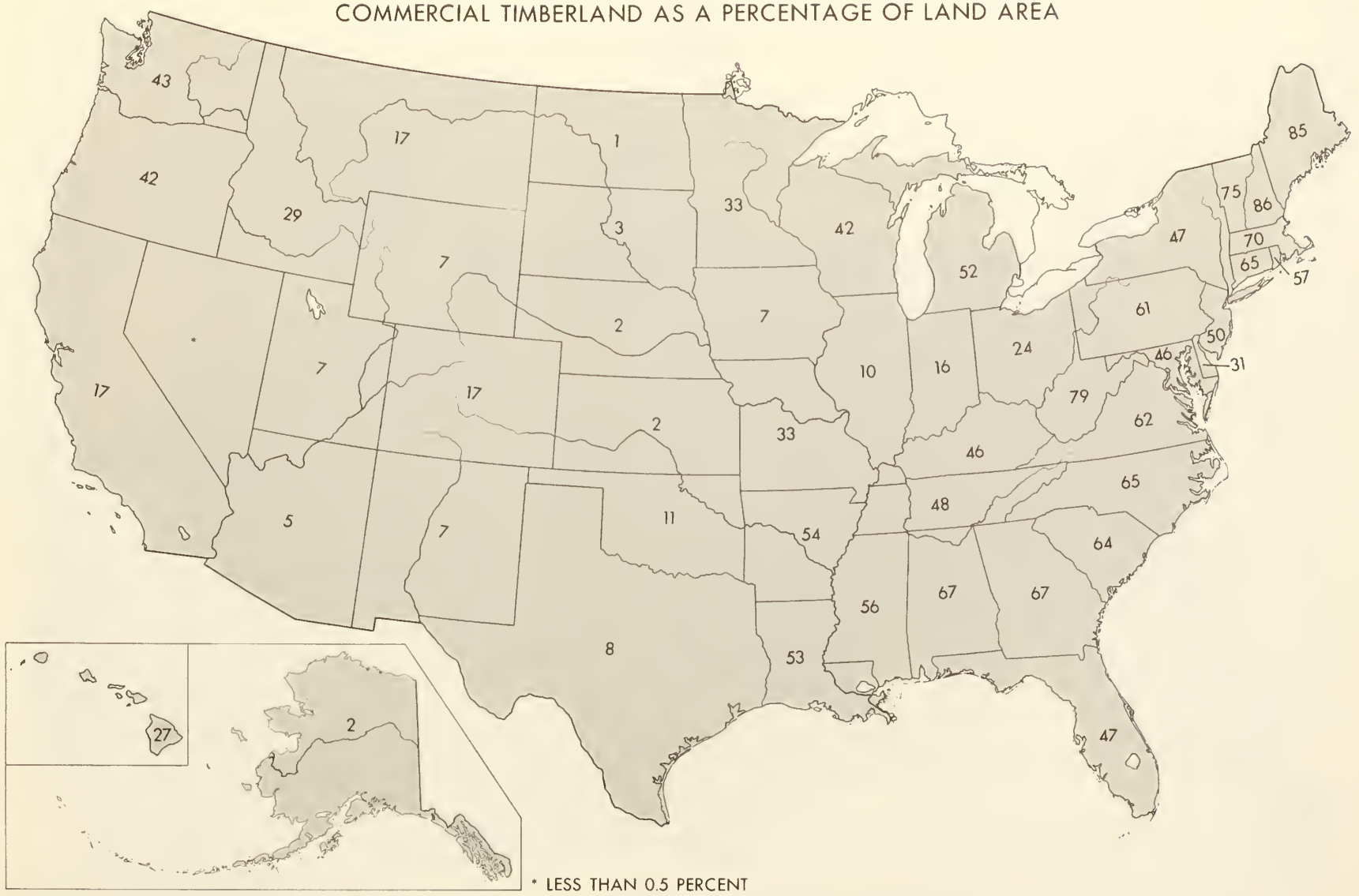

RANGELAND AND NONCOMMERCIAL FOREST AS A PERCENTAGE OF LAND AREA
30
64
27
4
2
2
8
2
2
45
51
50
85
2
91
79
49
50
59
28
1
3
2
3
2
82
85
39
1
1
6
59
2
10
94
* Less than 0.5 percent

Figure 5


COMMERCIAL TIMBERLAND AS A PERCENTAGE OF LAND AREA
43
42
29
17
1
3
7
2
33
42
52
47
85
75
86
70
65
57
61
50
46
31
24
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10
7
17
*
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17
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33
79
62
46
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48
5
7
11
54
64
56
67
67
8
53
47
27
2
* LESS THAN 0.5 PERCENT

Figure 6

of Oregon, Washington, and California; and the Rocky Mountain States of Montana, Idaho and Colorado.

Vegetation Characteristics

As a result of the large area and wide geographic distribution, the Nation's forest and range lands have a diversified vegetative cover ranging from moss, lichens, and short grasses, through high shrubs and cacti, to the huge trees of the Pacific Coast such as redwood and Douglas-fir. This diversified vegetation has been classified into 34 ecosystems in this study—14 nonforested and 20 forested. The nonforested ecosystems are based on the natural plant communities, termed phytocoenoses, of the United States as described by A. W. Kuchler in 1964 and 1966.[1] The forested ecosystems are based on the forest types used in the Forest Survey, conducted by the Forest Service.[2] Detailed descriptions of each ecosystem—vegetation, soils, animals, birdlife, and other features—are found in "Vegetation and Environmental Features of Forest and Range Ecosystems" by Garrison *et al.*[3]

Rangeland

Rangelands are highly variable. They occur from sea level to the highest mountains. Some are flat and smooth; others are steep, rough, and rocky. Rangelands may be dominated by short grasses, only 3 or 4 inches tall, such as the buffalograss of the Great Plains, or by grasses 6 to 8 feet tall, as big bluestem in the tall grass prairie. The vegetation includes such common and widespread shrubs as sagebrush and rabbitbrush, literally thousands of species of flowering forbs and grasses and even tall shrubs and some trees.

The most widespread of the rangeland ecosystems in the contiguous States is the plains grasslands with a total area of 173 million acres stretching northward from western Texas and eastern New Mexico to Canada (table 3). Large parts of this system are dominated by blue grama grass with buffalograss as a companion species in many areas. Wheatgrass and needlegrass dominate in the northeastern part of the area. Shrubs such as juniper, sagebrush, and buffaloberry are occasional in the northern reaches and rabbitbrush and mesquite in the southern parts.

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The plains grasslands—the most widespread of the rangeland ecosystems—has a high potential for production of forage.

East of the plains grasslands, where rainfall is somewhat higher, lies the prairie ecosystem with an area of about 38 million acres. In this tall grass or true prairie, the bluestem grasses, reaching heights of 5 to 6 feet, constitute about 70 percent of the vegetation. Woody vegetation is scarce and consists of willows on the exceptionally moist areas in the northern part of the system and scattered conifers and broadleaf deciduous trees in the southern part.

The plains and the prairie ecosystems once made up the "sea of waving grass" crossed by the pioneers in their wagon treks to the West. Now much of the original area is covered by pasture grasses, cereals such as corn and wheat, and other cultivated crops.

West of the plains grasslands, in the mountains and deserts, there are another 125 million acres on which the grass life form predominates. Nearly two-thirds of this area is mountain grasslands—an ecosystem characterized by bunchgrasses, such as fescues and wheatgrasses. Another fifth of this area is desert grasslands. The rest is in the alpine ecosystem, the annual grasslands of the California steppe, and mountain meadows.

In addition to the grasslands of the West shown in table 3, there are about 4.5 million acres in the wet grasslands consisting of coastal marshes and the palmetto prairies and Everglades of the southeastern United States. There are also more than 100 million acres of grasslands in Alaska, mainly on the lower Alaskan Peninsula and the Aleutian Islands.

The five shrub ecosystems—sagebrush, desert shrub, southwestern shrubsteppe, Texas savanna, and shinnery—cover 236 million acres in the contiguous States. The sagebrush system—the largest in

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[1] Kuchler, A. W. Potential natural vegetation of the conterminous United States. American Geographical Society, Special Publication No. 36, 116 pages with map. 1964.

Kuchler, A. W. (1966). Potential natural vegetation. P. 89–92 *in* the National Atlas of the United States of America, U.S. Department of the Interior, Geological Survey. 1970.

[2] U.S. Department of Agriculture, Forest Service. 1967. Geographic forest types used in the Forest Survey. Forest Service Handbook 4813.1, Sec. 74, March 1967.

[3] Garrison, George A., Ardell J. Bjugstad, Don A. Duncan, Mont E. Lewis, and Dixie R. Smith. Vegetation and environmental features of forest and range ecosystems. U.S. Department of Agriculture, Forest Service, Agric. Handb. 475, 68 p. (In press.)

Table 3. *Area of rangeland and noncommercial forest in the contiguous States, by ecosystem and State, 1970*

(*Thousand acres*)

State	Total	Grasslands[1]							Shrublands					Noncommercial forest[2]	
		Plains grass-lands	Prairie	Mountain grass-lands	Desert grass-lands	Annual grass-lands	Mountain meadows	Alpine[3]	Sage-brush	Desert shrub	South-western shrub steppe	Texas savanna	Shinnery	Chaparral-mountain shrub	Pinyon juniper
Arizona	58,581	.....	.....	6,191	6,327	.....	9	200	988	17,934	13,568	.....	.....	4,907	8,457
Arkansas	330	.....	330	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
California	40,330	.....	.....	4,293	.....	6,700	847	1,512	2,949	8,559	.....	.....	.....	13,651	1,819
Colorado	36,670	14,506	809	6,281	.....	.....	654	2,091	3,959	744	.....	.....	.....	2,207	5,419
Florida	258	.....	258	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Idaho	22,589	.....	.....	5,696	.....	.....	479	890	13,673	272	.....	.....	.....	1,186	393
Iowa	9	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kansas	14,341	12,114	2,227	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Louisiana	155	.....	155	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Minnesota	40	.....	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Missouri	20	.....	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Montana	53,070	31,153	.....	13,027	.....	.....	530	648	5,865	1,000	.....	.....	.....	846	1
Nebraska	23,900	9,618	14,282	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Nevada	63,425	.....	.....	7,436	70	.....	13	2	27,238	21,319	.....	.....	.....	2,829	4,518
New Mexico	64,535	15,564	.....	9,521	13,521	.....	346	77	1,714	4,506	7,608	.....	322	2,808	8,548
North Dakota	11,998	11,390	586	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	10
Oklahoma	12,493	10,908	1,218	.....	.....	.....	.....	.....	.....	.....	.....	.....	367	.....	.....
Oregon	25,141	.....	.....	7,989	.....	.....	247	711	13,064	977	.....	.....	.....	386	1,767
Pennsylvania	2	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
South Dakota	24,135	21,660	2,263	136	.....	.....	3	.....	21	.....	.....	.....	.....	52	.....
Texas	97,582	28,529	16,148	.....	2,412	.....	.....	.....	.....	16,268	17,425	15,221	1,315	220	44
Utah	40,576	.....	.....	6,495	3,768	.....	162	506	6,228	9,730	.....	.....	.....	1,992	11,695
Washington	8,915	.....	.....	6,167	.....	.....	204	617	1,657	.....	.....	.....	.....	270	.....
Wisconsin	27	.....	27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wyoming	48,362	17,818	.....	6,607	.....	.....	551	1,068	16,863	4,734	.....	.....	.....	715	6
Total	647,484	173,260	38,374	79,839	26,098	6,700	4,045	8,322	94,219	86,043	38,601	15,221	2,004	32,081	42,677

[1] Excludes wet grasslands. Data on the area in this ecosystem by State are shown in table 5.

[2] Lands used mainly for grazing. Excludes noncommercial forest land in other forest ecosystems.

[3] Includes barren areas above treeline.

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resource—a forest-range environmental study*, op. cit.

terms of area—has several grasses such as the wheatgrasses, fescues, bluegrasses, and bromegrasses in the understory. The desert shrub system—characterized by mesquite, blackbrush, saltbush, and creosotebush—is generally open with a large amount of bare soil and desert pavement exposed. The vegetative types on the Southwestern shrub ecosystem range from short grasses with scattered shrubs to shrubs with scattered areas of short grasses. Creosotebush and tarbush usually dominate in the shrub areas, and black grama, threeawns, and tobosa in the grass areas.

The Texas savanna is a high shrub system with a dense to open community of shrubs and grasses that vary from short to medium. Mesquite is the most widespread woody plant although other species such as oaks, acacia, juniper, and ceniza are common along the Rio Grande Valley and bluffs.

In Texas, Oklahoma, and New Mexico, there are small areas of shinnery—a midgrass prairie with open to dense stands of broadleaf deciduous shrubs. Common grasses are little bluestem and sideoats grama.

Approximately 100 million acres in Alaska, mainly on the lower Alaskan Peninsula and the Aleutian Islands, is wet or moist tundra (table 4). Most of the remaining area, chiefly on the arctic slope and the coastal lands of the Interior, is alpine tundra. Scattered through the area and especially in the tundra are large areas of barrens and muskeg.

The tundra ecosystems are characterized by low shrubs, grasses, sedges, flowering forbs, mosses, and lichens. Much of the tundra, and especially in the northern parts of the State, is underlain with permafrost, a phenomenon that plays a crucial role in determining both the land form and vegetation characteristics of these ecosystems.

Commercial Timberland

In contrast to the grasslands and shrublands—which are nearly all in the West and Alaska—three-quarters of the area in forest ecosystems[4] classified as commercial timberlands are in the East (table 5).

Oak-hickory forests, stretching from southern New England to Texas, represent the most widespread system, accounting for about 23 percent of all commercial timberlands in 1970. Much of this forest is located on abandoned farmlands and in mountain areas. Many stands include large proportions of less desirable timber species such as post oak, black oak, chestnut oak, and blackjack oak.

The oak-pine ecosystem is mainly in the South. It includes residual hardwoods left after cutting the merchantable pine trees from mixed pine-hardwood forests. In the last few decades, many oak-pine stands have been converted to pine stands by killing

[4] Forest ecosystems are synonymous with forest types as used by the Forest Survey.

Table 4. *Area of forest and range land in Alaska, by ownership and ecosystem, 1974*

(*Thousand acres*)

Ecosystem	Total	Federal			Non-Federal
		Bureau of Land Management	National Forest	Other Federal	
Nonforested					
Wet tundra	32,600	20,083	358	10,524	1,635
Moist tundra	65,500	44,436	—	19,429	1,635
Alpine tundra	88,400	71,446	4,515	10,322	2,117
High brush	17,600	12,525	218	4,110	747
Lowbrush-muskeg-bog	14,900	13,655	—	249	996
Total	219,000	162,145	5,091	44,634	7,130
Forested					
Western hemlock-Sitka spruce	14,500	990	11,770	570	1,170
Spruce-poplar	18,000	16,560	0	140	1,300
Upland spruce-hardwood	64,600	60,570	0	3,290	740
Lowland spruce-hardwood	35,100	31,700	0	1,770	1,630
Total	132,200	109,820	11,770	5,770	4,840
Total	351,200	271,965	16,861	50,404	11,970

Source: *Major ecosystems for Alaska*, op. cit.

Table 5. *Area of commercial timberland in the United States, by ecosystem,[1] 1970*

Ecogroups and ecosystems	Total area	Proportion of total
EASTERN GROUPS	*Thousand acres*	*Percent*
Softwoods:		
Loblolly-shortleaf pine	52,832	10.7
Longleaf-slash pine	18,315	3.7
Spruce-fir	18,913	3.8
White-red-jack pine	12,168	2.5
Total	102,228	20.7
Hardwoods:		
Oak-hickory	111,861	22.6
Oak-pine	35,028	7.1
Oak-gum-cypress	30,630	6.2
Maple-beech-birch	31,140	6.3
Elm-ash-cottonwood	24,728	5.0
Aspen-birch	20,484	4.1
Total	253,871	51.3
Nonstocked	14,343	2.9
Total East	370,442	74.9
WESTERN GROUPS		
Softwoods:		
Douglas-fir	30,788	6.2
Ponderosa pine	27,964	5.6
Fir-spruce	17,830	3.6
Lodgepole pine	13,235	2.7
Hemlock-Sitka spruce	10,819	2.2
Larch	2,743	.5
White pine	829	.2
Redwood	803	.2
Total	105,011	21.2
Hardwoods	12,818	2.6
Nonstocked	6,379	1.3
Total West	124,208	25.1
All groups	[2] 494,650	100.0

[1] Forest ecosystems are synonymous with forest types as used by the Forest Survey.

[2] Not including 5 million acres of "unregulated" commercial timberlands on National Forests in the Rocky Mountain States.

Source: *The outlook for timber in the United States*, op. cit.

or cutting hardwoods, followed in many cases by planting of pine trees.

Oak-gum-cypress forests include such valuable species as sweetgum, cherrybark oak, tupelo, and baldcypress, as well as less valuable species. Nearly all of this ecosystem occurs in the Mississippi Delta and other southern river bottoms where the land is highly productive.

Maple-beech-birch forests are found mainly on upland sites in the New England, Middle Atlantic, and Lake States regions. Elm-ash-cottonwood types are largely concentrated in bottomlands in the Central and Lake States regions. The aspen-birch forests are found chiefly in the Lake States region. These are the relatively short-lived pioneer species that have taken over large areas following logging and fires.

The southern pine ecosystem, the source of more than one-fourth of the timber harvest in the United States, made up a little more than 14 percent of the Nation's commercial timberlands in 1970. Southern pines are concentrated on the Coastal Plain and Piedmont extending from New Jersey to Texas.

Spruce-fir and white-red-jack pine forests in the Lake States and Northeast, while not as important as the southern pine system, also support substantial local industries.

In the West, the bulk of the commercial timberland is softwood ecosystems. The Douglas-fir and ponderosa pine systems each make up about 6 per-

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An oak-hickory forest—the most widespread timber type in the United States.

cent of the total commercial timberland in the United States, and other western softwoods 9 percent. Most Douglas-fir occurs on the Pacific Coast west of the Cascade Range where sites generally are highly productive. Douglas-fir also occurs in California and the Rocky Mountains, frequently on moderately productive sites and mixed with other coniferous species.

The ponderosa pine ecosystem occupies a large acreage in eastern Oregon and Washington and is the most extensive commercial forest type in California and the Rocky Mountains.

Noncommercial Forest

The data in table 5 include only commercial timberland. In most forest ecosystems, and especially those in the West, there are substantial additional acreages classified as noncommercial forest (tables 6 and 7). For example, the total area in the ponderosa pine ecosystem is estimated at 37.6 million acres, some 9.6 million acres greater than the estimate of commercial area.

Some of the area—about 20 million acres—classified as noncommercial is productive timberland used for parks, wilderness, and other purposes not compatible with the production of timber. The bulk of this land is in the mountainous regions of the West. There are also substantial acreages that cannot meet the minimum standards for commercial timberland because of poor sites or other adverse conditions.

There are also two forested ecosystems—the chaparral-mountain shrub and the pinyon-juniper—which are classified as noncommercial because they do not meet the minimum growth and tree form standards for commercial timberland (table 3). The 75 million acres in these two ecosystems—located in semiarid areas in the West and mostly used for grazing—account for a substantial part of the noncommercial forest area.

There are 114 million acres of noncommercial forest land in Alaska, nearly all in the interior. White spruce is the most important species but there are also large areas of quaking aspen and paper birch, the pioneer species which seed in after fires. Cottonwood is also common along the streams.

The interior forest ecosystems are characterized by open forest stands with shrubby and mossy understories. The so-called "reindeer moss," actually a lichen, is a common and important understory plant which provides important winter forage to native caribou.

An estimated 12.6 million acres of Alaska's interior forests meet the minimum standards for commercial timberland. However, because of geographic remoteness and potentially high development costs, none of this area has been included in the tables showing commercial timberland area in this study.

Ownership

The great bulk of the Nation's forest and range land in the contiguous States is in private ownership. In 1970, the area in these ownerships, plus relatively small areas in State, county, and municipal ownerships, amounted to 825 million acres—about 70 percent of the forest and range land area. Most of the Federal lands are administered by two agencies, the Forest Service, responsible for 166 million acres of National Forest System lands and the Bureau of Land Management, for 168 million acres of National Resource Lands. The rest of the Federal land is administered primarily by the National Park Service and the Fish and Wildlife Service in the Department of the Interior and the Department of Defense (table 8).

Table 6. *Area of western forest by ecosystem and State, 1970*

(*Thousand acres*)

State	Total	Douglas-fir	Ponderosa pine	Western white pine	Fir-spruce	Hemlock-Sitka spruce	Larch	Lodgepole pine	Redwood	Hardwoods
Arizona	4,578	137	4,251	.....	111	.....	.....	.....	.....	79
California	26,208	3,552	7,748	26	3,489	35	.....	426	923	10,009
Colorado	14,306	1,501	2,419	262	4,524	.....	.....	2,363	.....	3,237
Idaho	19,693	7,132	2,075	1,349	3,050	780	2,117	2,523	.....	667
Montana	22,255	5,569	3,870	1,447	2,345	69	2,158	6,293	.....	504
Nebraska	316	.....	316	.....	.....	.....	.....	.....	.....	.....
Nevada	538	21	103	168	143	61	.....	13	.....	29
New Mexico	6,894	1,122	4,680	43	651	.....	.....	.....	.....	398
Oregon	28,452	10,246	6,412	71	3,686	1,659	112	2,315	5	3,946
South Dakota	1,454	.....	1,421	.....	23	.....	.....	.....	.....	10
Utah	4,538	752	465	38	1,250	.....	.....	604	.....	1,429
Washington	22,417	7,886	2,816	78	3,050	4,472	757	852	.....	2,506
Wyoming	8,980	1,017	992	571	2,062	.....	.....	3,754	.....	584
Total	160,629	38,935	37,568	4,053	24,384	7,076	5,144	19,143	928	23,398

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

Table 7. *Area of eastern forest by ecosystem and State, 1970*

(*Thousand acres*)

State	Total	White-red-jack pine	Spruce-fir	Longleaf-slash pine	Loblolly-shortleaf pine	Oak-pine	Oak-hickory	Oak-gum-cypress	Elm-ash-cotton-wood	Maple-beech-birch	Aspen-birch	Wet grass-lands
Alabama	21,755	.....	.....	1,986	7,481	4,865	5,042	2,280	94	.....	.....	7
Arizona	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	45
Arkansas	18,413	.....	.....	.....	3,734	3,064	8,460	2,771	274	.....	.....	110
California	156	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	156
Colorado	27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	27
Connecticut	1,992	96	.....	.....	.....	.....	1,391	.....	298	109	98	.....
Delaware	397	.....	.....	.....	198	22	83	89	.....	.....	.....	5
Florida	19,276	.....	.....	7,905	1,386	1,064	1,270	5,528	85	.....	.....	2,038
Georgia	27,491	19	.....	6,314	8,481	3,782	3,657	5,154	.....	.....	.....	84
Idaho	35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	35
Illinois	3,807	.....	.....	.....	45	12	2,256	16	1,442	14	9	13
Indiana	3,902	3	.....	.....	57	41	2,421	55	535	781	9	.....
Iowa	2,482	.....	.....	.....	.....	.....	1,251	.....	1,113	72	18	28
Kansas	1,360	.....	.....	.....	.....	2	764	.....	580	.....	.....	14
Kentucky	11,776	.....	.....	36	701	557	9,272	130	751	304	.....	25

Louisiana	15,669	.....	.....	1,200	4,315	2,202	1,402	5,540	658	.....	.....	352
Maine	17,844	1,672	8,876	.....	.....	.....	288	.....	523	5,224	1,256	5
Maryland	2,978	39	12	.....	609	299	1,453	371	130	43	10	12
Massachusetts	3,289	577	28	.....	165	221	1,262	.....	277	468	285	6
Michigan	19,478	2,011	3,399	.....	.....	.....	2,121	.....	1,789	5,341	4,793	24
Minnesota	19,473	1,542	5,889	.....	.....	.....	1,330	.....	2,098	1,033	7,526	55
Mississippi	16,995	.....	.....	1,320	4,255	3,410	4,330	3,286	342	.....	.....	52
Missouri	14,959	.....	.....	.....	361	661	11,463	402	1,985	77	.....	10
Montana	139	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	139
Nebraska	742	.....	.....	.....	.....	.....	189	.....	540	.....	.....	13
Nevada	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
New Hampshire	5,155	1,423	1,190	.....	.....	.....	617	.....	121	1,346	458	.....
New Jersey	2,247	17	.....	.....	821	130	806	.....	397	38	21	17
New Mexico	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
New York	17,188	1,827	1,561	.....	.....	302	1,356	.....	3,397	7,428	1,309	8
North Carolina	20,716	134	18	513	6,715	3,604	6,363	2,695	319	307	.....	48
North Dakota	545	.....	.....	.....	.....	.....	95	.....	212	.....	140	98
Ohio	6,433	55	19	11	196	487	3,003	29	1,388	1,177	65	3
Oklahoma	9,551	.....	.....	6	807	685	7,583	339	113	.....	.....	18
Oregon	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30
Pennsylvania	17,060	952	.....	.....	208	142	7,981	200	2,072	3,565	1,938	2
Rhode Island	431	8	.....	.....	10	27	283	.....	76	.....	27	.....
South Carolina	12,582	9	.....	1,121	4,575	2,196	2,535	1,802	284	.....	.....	60
South Dakota	306	.....	.....	.....	.....	.....	68	.....	223	.....	.....	15
Tennessee	13,831	141	16	85	1,348	1,360	9,711	681	219	237	.....	33
Texas	15,129	.....	.....	348	5,089	2,422	4,276	2,295	81	.....	.....	618
Utah	67	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	67
Vermont	4,370	601	764	.....	.....	63	111	.....	557	2,019	252	3
Virginia	16,615	65	.....	.....	2,998	2,729	10,327	263	135	78	.....	20
Washington	69	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	69
West Virginia	11,480	88	92	44	540	115	7,503	148	611	2,339	.....	.....
Wisconsin	15,151	1,277	1,731	.....	.....	.....	2,756	.....	1,319	3,633	4,350	85
Wyoming	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25
Total	393,481	12,556	23,595	20,889	55,095	34,464	125,079	34,074	25,038	35,633	22,564	4,494

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

Table 8. *Area of forest and range land in the contiguous States, by ownership and ecosystem, January 1970*[1]

(*Million acres*)

Ecosystems	Total	National Forest System	National Resource Lands[2]	Other[3] Federal	Non-Federal
Rangelands					
Grasslands					
Plains grasslands	173.3	3.6	5.1	1.7	162.9
Prairie	38.4	0.3	0	.2	37.9
Mountain grasslands	79.8	7.2	5.2	.4	67.0
Desert grasslands	26.1	1.2	6.2	3.4	15.3
Annual grasslands	6.7	0	.4	([4])	6.3
Mountain meadows	4.0	1.9	.1	([4])	2.0
Alpine[5]	8.3	8.3	0	([4])	0
Wet grasslands[6]	4.5	([4])	0	2.7	1.7
Total	341.1	22.5	17.0	8.4	293.1
Shrub lands					
Sagebrush	94.2	10.0	64.2	3.0	17.1
Desert shrub	86.0	5.0	50.4	4.9	25.8
Southwestern shrubsteppe	38.6	1.1	8.1	2.2	27.2
Texas savanna	15.2	([4])	0	.1	15.1
Shinnery	2.0	.1	([4])	([4])	1.9
Total	236.0	16.2	122.7	10.2	87.1
Total rangelands	577.1	38.7	139.7	18.6	380.2
Noncommercial forests					
Pinyon-juniper	42.7	10.2	18.1	.9	13.5
Chaparral-mountain shrub	32.1	6.7	6.7	6.1	12.6
Total	74.8	16.9	24.8	7.0	26.1

Ecosystems	Total	National Forest System	National Resource Lands[2]	Other[3] Federal	Non-Federal
Western Forests					
Douglas-fir	38.9	20.2	1.2	2.1	15.4
Ponderosa pine	37.6	19.2	2.1	1.5	14.8
Western white pine	4.1	3.5	([4])	.1	0.5
Fir-spruce	24.4	18.4	.2	1.6	4.2
Hemlock-Sitka spruce	7.1	2.2	0	.5	4.4
Larch	5.1	3.3	([4])	.2	1.6
Lodgepole pine	19.1	13.5	.1	2.5	3.0
Redwood	0.9	([4])	0	.1	.8
Hardwoods	23.4	6.8	0	1.7	14.9
Total	160.6	87.1	3.6	10.3	59.6
Eastern Forests					
White-red-jack pine	12.6	1.5	0	0.1	10.9
Spruce-fir	23.6	2.2	0	.2	21.2
Longleaf-slash pine	20.9	1.1	0	.8	19.0
Loblolly-shortleaf pine	55.1	3.6	0	.7	50.7
Oak-pine	34.5	2.2	0	.7	31.6
Oak-hickory	125.1	6.8	0	2.0	116.2
Oak-gum-cypress	34.1	0.5	0	1.2	32.4
Elm-ash-cottonwood	25.0	.3	0	.2	24.5
Maple-beech-birch	35.6	2.7	0	.2	32.8
Aspen-birch	22.6	2.4	0	.2	20.0
Total	389.1	23.3	0	6.3	359.4
All States	1,201.6	165.9	168.1	42.2	825.3

[1] Columns may not add to totals because of rounding.

[2] Administered by Bureau of Land Management, Department of the Interior. Data supplied by Bureau of Land Management, 1970.

[3] Administered chiefly by Agencies of the Department of the Interior (excluding Bureau of Land Management) and Department of Defense.

[4] Less than 50,000 acres.

[5] Includes barren areas above treeline.

[6] Occurs throughout much of coastal United States.

Source: *The nation's range resources—a forest-range environmental study*, op. cit.

Rangeland

Rangeland on which grasses and other herbaceous forms predominate is even more heavily concentrated in non-Federal ownerships. In 1970, some 99 percent of the prairie grasslands, 94 percent of the plains grasslands, and 84 percent of the mountain grasslands were in these ownerships, nearly all private.

In contrast, Federal ownership predominated on most of the shrub ecosystems. Some 82 percent of the sagebrush system and 70 percent of the desert shrub was in Federal holdings.

Federal ownership was also dominant on the noncommercial forest ecosystems—chaparral-mountain shrub and pinyon-juniper—in the contiguous States.

It was also the dominant ownership in Alaska where nearly all of the rangeland and noncommercial forest is Federally owned (table 4). However, under the provisions of the Alaska Statehood Bill of 1958, 103 million acres, including a small area of commercial timberland, will be transferred to the State. Another 45 million acres will be transferred to Alaskan Natives under the provisions of the "Alaska Native Claims Settlement Act of 1971."

Most of the rangeland and noncommercial forest, both in the contiguous States and Alaska, is administered by the Department of Interior, chiefly the Bureau of Land Management. Nearly all of the area is public domain land that was never transferred from Federal ownership. Most of this land was not considered suitable for private development because of climate, topography, or other adverse factors. Part of the area, largely that in National Parks and National Forests, was reserved from disposition under the settlement laws to meet other objectives of the Federal Government.

Commercial Timberland

About 73 percent of all commercial timberland was privately owned in 1970 while 27 percent was in Federal, State, and other public holdings (table 9).

Business and professional people; wage and salaried workers; housewives; railroad, mining, and other corporations (other than forest industry); and other nonfarm owners held 165 million acres, or 33 percent of the total area of commercial timberland. Another 26 percent was owned by farmers.

Many of the farm and nonindustrial private holdings include highly productive timber sites, and most are close to markets for timber products. These ownerships consequently have long been of major importance as a source of timber supplies for the wood-using industries. Nearly half of these timberlands was in the South in 1970 and most of the remainder in the North.

The 67 million acres of commercial timberland in forest industry holdings in 1970—about 14 percent of the total—included some of the Nation's most productive timber growing areas. About 52 percent of these industrial lands were in the South, and 26

Table 9. *Area of commercial timberland in the United States, by section and ownership, January 1, 1970*

Type of ownership	Total United States		North	South	Rocky Mountains	Pacific Coast
	Area	Proportion				
Federal:	*Thousand acres*	*Percent*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
National Forest	91,924	18	10,458	10,764	[2]39,787	30,915
Bureau of Land Management	4,762	1	75	11	2,024	2,652
Bureau of Indian Affairs[1]	5,888	1	815	220	2,809	2,044
Other Federal	4,534	1	963	3,282	78	211
Total Federal	107,109	21	12,311	14,277	44,699	35,822
State	21,423	4	13,076	2,321	2,198	3,828
County and municipal	7,589	2	6,525	681	71	312
Forest industry	67,341	14	17,563	35,325	2,234	12,219
Farm	131,135	26	51,017	65,137	8,379	6,602
Miscellaneous private	165,101	33	77,409	74,801	4,051	8,840
All ownerships	499,697	100	177,901	192,542	61,632	67,623

[1] Lands held in common by Indian Tribal Groups.

[2] Includes 5 million acres classified as "unregulated" commercial timberland.

Note: Columns may not add to totals because of rounding.

Source: *The outlook for timber in the United States*, op. cit.

percent in the North. Most of the remaining areas were on the Pacific Coast, and largely composed of the more productive lower elevation lands.

Some 92 million acres of commercial timberlands, or 18 percent of the U.S. total, were in National Forests in 1970. These forests were located largely in the Rocky Mountain and Pacific Coast sections. Most are of relatively low site quality and located at higher elevations, but they nevertheless contain a substantial part of the Nation's softwood sawtimber inventory, as pointed out in a later section of this report.

Federal lands other than National Forests made up 3 percent of all commercial timberlands in 1970. Lands in western Oregon administered by the Bureau of Land Management and Bureau of Indian Affairs were of particular importance. State, county, and municipal forests made up 6 percent of the total. Many of these latter holdings are located in the Lake States, and largely consist of cutover lands that reverted through tax delinquency to public ownership during the depression years of the 1930's.

Productivity of Forest and Range Land

Rangeland

As a result of differences in climate, soils, and elevation, the productivity of the Nation's rangelands varies widely. In 1970, about a quarter of the area in the contiguous States was in the lowest productivity class with another three-fifths in the moderately low class (table 10). A large proportion of the lands in these lower classes was in National Forest and other Federal ownership. Only 4 percent of the area was estimated to be in the high productivity class.

Nearly three-quarters of the rangeland was in fair or poor condition, i.e., was producing less than 60 percent of its potential. Most of the land in good condition (producing 60 percent or more of its potential) was in the plains and prairie grasslands ecosystems.

Some level of fire protection is provided for most rangeland. Seventy-three million acres is still unprotected.

Commercial Timberland

About 10 percent of the 495 million acres of commercial timberlands was capable of producing 120 cubic feet or more per acre per year in fully stocked natural stands (table 11). (Under intensive management, greater productivity could be achieved.) Nearly half of the highly productive land is in the Pacific Coast section, and is largely forested with Douglas-fir, hemlock-sitka spruce, and western hardwoods.

Nearly two-thirds of the total area of commercial timberland is in the 85 to 120 and the 50 to 85 cubic foot productivity classes. About half of this acreage is in the South.

The remaining area, more than a quarter of all commercial timberlands, is in the 20 to 50 cubic foot productivity class. This class of land provides limited reponse to timber management but often yields important values for grazing, recreation, or other nontimber uses. These lower site lands are mostly in the Appalachians and the Rocky Mountains where they make up about half of the commercial area.

A relatively large proportion of the better sites above 85 cubic feet productivity is in forest industry ownerships. The National Forests and other public ownerships have relatively high proportions of the poorer sites of less than 50 cubic feet potential.

The potential yields indicated by site productivity classes are generally not attained, even though practically all commercial timberlands in 1970 were occupied to some extent by some type of tree cover, and many forests were fully stocked or even overstocked in terms of all live trees. However, only a small proportion of the land supported desirable trees of good form, vigor, and preferred species. Growing stock of acceptable trees, and trees classed as rough and rotten, made up most of the stocking. Thus, large areas require cultural treatments such as cull tree removal or thinning to achieve a high level or output of merchantable timber and approach the yield potentials indicated by indexes of site productivity.

Most of the commercial timberland has some degree of fire protection. Some 13 million acres, however, are without protection and are subject to uncontrolled fires.

Trends in Area

There are no reliable quantitative data available showing national trends in rangeland areas. No complete national inventory of these lands has been made. Nor have periodic partial inventories that have been made used identical land type definitions and standards. However, data assembled for the Western Range Survey and reported in 1936[5] indicated that there were 601.8 million acres of range types as then defined. A 1970 estimate[6] of rangeland acreage for essentially the same area covered in 1936 indicated 647.5 million acres. This suggests an increase in acreage. However, this may not be a real change because of lack of a common data base and varying type definitions.

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[5] U.S. Department of Agriculture, Forest Service. The western range. Sen. Doc. No. 199 (74th Cong., 2nd Sess.) U.S. Government Printing Office. 620 p. 1936.

[6] U.S. Department of Agriculture, Forest Service. The Nation's range resources—a forest-range environmental study. Forest Resource Rpt. 19, 147 p. 1972.

Table 10. *Area of rangeland and noncommercial forest in the contiguous States, by productivity, condition class, and ecosystem, 1970*

(Thousand acres)

Nonforested ecosystems	Total productivity				High productivity				Moderately high productivity				Moderately low productivity				Low productivity			
		Condition class				Condition class				Condition class				Condition class				Condition class		
	Total	Good	Fair	Poor	Total	Good	Fair	Poor	Total	Good	Fair	Poor	Total	Good	Fair	Poor	Total	Good	Fair	Poor
Grasslands																				
Plains grasslands	173,260	93,063	73,249	6,948	6,131	4,317	1,502	312	31,471	29,912	1,188	371	128,886	58,787	69,592	507	6,772	47	967	5,758
Prairie	38,374	17,449	19,148	1,777	191	54	119	18	7,334	7,207	52	75	28,702	10,180	18,502	20	2,147	8	475	1,664
Mountain grasslands	79,839	36,025	36,096	7,718	4,783	2,913	1,656	214	12,400	9,499	2,267	634	56,996	23,601	31,872	1,523	5,660	12	301	5,347
Desert grasslands	26,098	7,821	12,722	5,555	1,331	992	291	48	5,595	2,464	2,621	510	15,870	4,352	9,630	1,888	3,302	13	180	3,109
Annual grasslands	6,700	2,581	3,841	278	11	11	...	...	1,032	805	227	.....	5,494	1,759	3,606	129	163	6	8	149
Mountain meadows	4,045	1,689	1,557	799	1,304	578	524	202	622	364	135	123	1,675	745	895	35	444	2	3	439
Alpine[1]	8,322	70	103	8,149	120	57	55	8	66	6	35	25	36	6	11	19	8,100	1	2	8,097
Total	336,638	158,698	146,716	31,224	13,869	8,922	4,147	802	58,520	50,257	6,525	1,738	237,659	99,430	134,108	4,121	26,588	89	1,936	24,563
Shrub lands:																				
Sagebrush	94,219	4,372	48,550	41,297	4,760	3,184	1,511	65	21,925	325	19,303	2,297	32,741	449	19,049	13,243	34,793	414	8,687	25,692
Desert shrub[2]	86,043	10,259	49,833	25,951	318	303	14	1	5,680	3,753	1,675	252	15,764	3,582	11,268	914	64,281	2,621	36,876	24,784
Southwestern shrubsteppe	38,601	7,119	21,888	9,594	710	405	264	41	5,970	3,331	2,377	262	23,526	3,271	16,957	3,298	8,395	112	2,290	5,993
Texas savanna	15,221	74	8,540	6,607	4	2	1	1	26	6	16	4	10,041	59	7,536	2,446	5,150	7	987	4,156
Shinnery	2,004	30	1,849	125	72	30	24	18	7	.....	.....	7	1,843		1,802	41	82		23	59
Total	236,088	21,854	130,660	83,574	5,864	3,924	1,814	126	33,608	7,415	23,371	2,822	83,915	7,361	56,612	19,942	112,701	3,154	48,863	60,684
Noncommercial forest																				
Pinyon-juniper	42,677	2,415	17,909	22,353	2,030	734	1,242	54	3,588	125	2,779	684	13,620	848	9,329	3,443	23,439	708	4,559	18,172
Chaparral-mountain shrub	32,081	1,469	16,881	13,731	1,109	516	553	40	4,889	291	4,038	560	9,075	488	6,884	1,703	17,008	174	5,406	11,428
Total	74,758	3,884	34,790	36,084	3,139	1,250	1,795	94	8,477	416	6,817	1,244	22,695	1,336	16,213	5,146	40,447	882	9,965	29,600
Total	647,484	184,436	312,166	150,882	22,874	14,096	7,756	1,022	100,605	58,088	36,713	5,804	344,269	108,127	206,933	29,209	179,736	4,125	60,764	114,847

[1] Includes barren areas above tree line. For statistical reasons, 8 million acres of naturally barren areas above tree line were accounted for in the low productivity, poor condition class.

[2] Includes proximate salt flats and playas.

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

Table 11. *Area of commercial timberland in the United States, by section, site productivity class, and ecosystem, 1970*

(Million acres)

Ecosystem	Total United States[1] productivity class[2]					North productivity class[2]					South productivity class[2]					Rocky Mountain[1] productivity class[2]					Pacific Coast productivity class[2]				
	120 or more	85 to 120	50 to 85	20 to 50	Total	120 or more	85 to 120	50 to 85	20 to 50	Total	120 or more	85 to 120	50 to 85	20 to 50	Total	120 or more	85 to 120	50 to 85	20 to 50	Total	120 or more	85 to 120	50 to 85	20 to 50	Total
Eastern forest:																									
White-red-jack pine	1.2	2.4	5.1	3.5	12.2	1.1	2.4	5.0	3.4	11.9	0.1	(3)	0.1	(3)	0.2	....		.....	..				.	....	
Spruce-fir	1.9	4.0	6.2	6.7	18.9	1.9	4.0	6.2	6.7	18.9	.	..	(3)	(3)	(3)	....		.....			.....			....	
Longleaf-slash pine	0.8	5.5	8.8	3.1	18.3	....	..	.....	.....	.....	.8	5.5	8.8	3.1	18.3	....		.....	....		.....			....	
Loblolly-shortleaf pine	5.0	18.1	24.3	5.4	52.8	0.1	1.8	1.3	0.2	3.4	4.9	16.3	23.1	5.2	49.4	....		.....	.....		.....			....	
Oak-pine	3.0	9.6	16.8	5.7	35.0	.3	1.4	1.4	1.0	4.1	2.6	8.2	15.4	4.7	30.9	....	..	.....	.....	.	.....			....	
Oak-hickory	4.5	24.7	49.4	33.2	111.9	2.6	15.4	21.0	16.5	55.5	1.9	9.3	28.5	16.7	56.3	....	..	.....	.....	...	.....			....	
Oak-gum-cypress	2.4	13.3	11.5	3.4	30.6	(3)	0.5	0.6	.3	1.4	2.4	12.8	10.9	3.1	29.3	....	.	.....	.....	..	..			....	
Elm-ash-cottonwood	1.8	5.0	9.5	8.4	24.7	1.2	3.9	8.7	8.2	22.0	.7	1.0	.8	0.2	2.8	....	.	..	.....	...	.	.		....	
Maple-beech-birch	1.9	5.8	11.9	11.5	31.1	1.9	5.8	11.6	11.4	30.7	(3)	0.1	.3	.1	.5	....	..	..	.....	...	.	.....		.	
Aspen-birch	.5	3.3	10.2	6.5	20.5	.5	3.3	10.2	6.5	20.5	....	.....	..	.....	..	....	..	..	.....	..	.	...		....	
Nonstocked	.2	1.0	4.8	8.3	14.3	.1	.8	3.1	5.5	9.6	.1	.3	1.7	2.8	4.8	....	..	..	.....	..	.	....		....	
Total Eastern	23.2	92.8	158.6	95.7	370.4	9.8	39.3	69.0	59.8	177.9	13.5	53.5	89.6	36.0	192.5	.	.	.....	.....	.....	.	.....	.		
Western forest:																									
Douglas-fir	8.9	5.6	10.1	6.2	30.8	....	....	....	.....	.	....	.		.....	....	1.1	2.0	3.6	5.2	11.9	7.9	3.6	6.5	1.0	18.9
Ponderosa pine	2.0	4.0	9.4	12.6	28.0	....	..	..	.....	.	.....	..	..	....	....	0.3	0.7	3.2	10.3	14.5	1.7	3.3	6.2	2.3	13.5
Western white pine	.5	0.2	0.1	(3)	0.8	....	....	....	.....	.	.....	..	....	.....	.....	.4	1	0.1	(3)	0.6	(3)	0.1	(3)	(3)	0.2
Fir-spruce	3.2	3.9	6.0	4.7	17.8	....	....	....	.....	.	.....	.	.	..	..	.8	1.9	3.1	4.0	9.8	2.3	2.0	2.9	0.7	8.0
Hemlock-sitka spruce	5.4	3.1	1.9	0.4	10.8	....	....	....	.....	.	.....	.....	.	.....	.....	.2	.3	.2	0.2	.9	5.2	2.8	1.7	2	9.9
Larch	.9	.7	.9	.2	2.7	....	.....	....	.....	.	.....	.....	.	.....	.....	.8	.5	.6	.1	2.0	0.1	.2	0.3	1	.7
Lodgepole pine	.8	2.7	4.2	5.6	13.2	....	.....	.....	.....	.	.....	.....	.....	.....	.....	.8	1.8	2.1	5.2	9.9	(3)	.9	2.0	3	3.3
Redwood	.7	.1	(3)	.....	.8	..	....	....	.....	.	....	....	....	.....	.....	....	....	....	....	....	.7	.1	(3)	..	.8
Western hardwoods	4.3	2.2	2.6	3.8	12.8	....	.....	....	.....	.	.....	.....	.....	.....	.....	.1	.2	.6	3.3	4.3	4.2	1.9	2.0	.4	8.5
Nonstocked	1.7	1.0	1.6	2.2	6.4	..	.....	....	.....	.....	.....	....	....	....	....	.2	.3	.5	1.7	2.7	1.5	.7	1.1	.4	3.7
Total Western	28.4	23.4	36.8	35.7	124.2	...	.....	....	.....	.....	.....	....	....	.....	.....	4.7	7.8	13.9	30.2	56.6	23.6	15.6	22.9	5.5	67.6
Total	51.6	116.2	195.4	131.4	494.6	9.8	39.3	69.0	59.8	177.9	13.5	53.5	89.6	36.0	192.5	4.7	7.8	13.9	30.2	56.6	23.6	15.6	22.9	5.5	67.6

[1] Excludes 5 million acres of National Forest lands in the Rocky Mountains class as "unregulated" commercial timberlands.

[2] A measure of the net annual growth attainable in cubic feet per acre in fully stocked natural stands.

[3] Less than 50 thousand acres.

Source: *The outlook for timber in the United States*, op. cit.

Grassland areas, and especially the prairie grasslands, are much smaller than they were at the time the country was settled. Much of the higher producing crop land of the Midwest was natural prairie before it was converted. However, present grassland areas may be larger than in the decades before the "dust bowl" of the 1930's and the subsequent reversion of marginal semiarid cropland to grass.

There has also been some increase in noncommercial forest land in recent decades, primarily as a result of the establishment of parks, wilderness, and other reserved forested areas.

The available data indicate that the area of commercial timberland declined rather steadily after settlement as the land was cleared for crops and pastures. This trend continued until around 1920 when reversion began over large parts of the East. Between 1920 and the early 1960's, the acreage of commercial forest increased by about 50 million acres as the worked-out cottonlands in the South and cleared acres on hill farms in the East and the poorer farms in the other regions came back to forests.

The successional reversion of idle and abandoned crop and pasture land to pine forests in the South in this period had major impacts on softwood timber supplies and the development of timber-based industries in that section. As this timber is harvested, the task of maintaining pine timber supplies will become increasingly more difficult because the cutover land tends to naturally restock with hardwoods.

Around the beginning of the 1960's, the upward trend in total acreage again reversed and between 1962 and 1970, the area of commercial timberland in the United States dropped by over 8 million acres (table 12). Forest Survey reports covering years after 1970 indicate the drop is continuing.

The 8 million acre decline between 1962 and 1970 was the net change in area. Net changes are often much smaller than the area moving out of commercial status. For example, about 1.7 million acres of timberlands were shifted to cropland, pastureland, urban, and other uses in Florida between 1959 and 1970. This was substantially above the net loss of 1 million acres. This difference is important because timberlands shifted to other uses usually contain inventories that are either largely destroyed or reserved. The reverting acreage, on the other hand, is nonstocked or understocked abandoned crop or pastureland that remains unproductive for many years.

Recent declines in commercial timberland were largely in the South and Rocky Mountains. Much of the reduction in the Rocky Mountains and in other

Table 12. *Area of commercial timberland in the United States, by region, 1952, 1962, and 1970*

(*Thousand acres*)

Region	1952	1962	1970	Change 1962–1970
New England	30,935	31,878	32,367	+488
Middle Atlantic	42,098	46,737	49,685	+2,947
Lake States	52,604	51,530	50,841	−690
Central	44,559	44,942	45,008	+66
Total North	170,198	175,089	177,901	+2,812
South Atlantic	46,962	47,911	48,463	+551
East Gulf	42,104	43,128	41,334	−1,794
Central Gulf	49,497	53,361	51,454	−1,907
West Gulf	53,518	55,504	51,291	−4,214
Total South	192,082	199,905	192,542	−7,364
Pacific Northwest	50,589	50,407	49,713	−694
Pacific Southwest	18,216	18,132	17,909	−223
Northern Rocky Mountain	38,337	38,792	36,669	−2,124
Southern Rocky Mountain	25,554	25,810	24,963	−848
Total West	132,696	133,141	129,254	−3,888
All regions	494,978	508,137	499,697	−8,440

Note: Data for 1952 and 1962 as published in earlier reports have been revised to insure comparability with 1970 definitions and local specifications of commercial timberland.

Source: *The outlook for timber in the United States*, op. cit.

parts of the West reflected shifts of public lands in National Forests to reserved or deferred status in response to growing demands for public recreational uses.

In the South, much clearing of commercial timberland for soybean and other crop production has taken place in recent years, particularly on the flood plains of the Mississippi and other major southern rivers. In addition, extensive areas of forest uplands were converted to pasture for the South's growing cattle industry. In all regions, sizeable areas of forest land also have been taken over for suburban development, highways, reservoirs, and other nontimber uses.

Shifts in land use patterns and natural succession have also caused many important changes in forest ecosystems. Bottomland hardwood forests were reduced about 20 percent between 1962 and 1970 by clearing of forest land along the deltas of the Mississippi River and its tributaries for farm crops. For many years, forests of the oak-gum-cypress group in this area supplied a major share of the Nation's quality hardwood sawtimber.

Many changes have also been apparent in areas formerly supporting Douglas-fir. Red alder, other hardwoods, or western hemlock have taken over sizeable areas after harvesting of the softwood stands. Western hardwood types, for example, increased by almost 2 million acres between 1962 and 1970.

There have also been some important shifts in the ownership of commercial timberlands. Since 1952, the combined area of farm and nonindustrial private land has not shown much change. However, farm ownership dropped about 42.5 million acres between 1952 and 1970, while other nonindustrial ownerships increased about the same amount.

In the 1952–70 period, areas of commercial timberland in forest industry ownerships increased 13 percent—close to 8 million acres. Much of the increase was in the South where wood-using companies have been actively acquiring forest lands. A substantial part of the added acreage was purchased from farm and other nonindustrial private owners.

Forest industries have also turned to leasing and long-term cutting contracts to supplement fee ownership. In the South, an estimated 9 million acres of commercial timberland in nonindustrial ownerships was managed by forest industries in 1970.

Between 1962 and 1970, the area in National Forests classed as commercial timberland was reduced about 3 million acres. This reduction was largely in the Rocky Mountain section, and was mainly composed of lands selected for study as possible inclusions in the wilderness system. Since 1970, some additional areas also have been added to this deferred classification.

Major Uses

The Nation's forest and range lands, and the associated inland waters, are used for many purposes. These vary from the appreciation of natural beauty through maintenance of soil, air, and water quality to the production of goods such as forage and timber that are important raw materials in the economy. Although analyses of prospective demands for all uses have not been included in this assessment, the anticipated growth in population and economic activity indicates that demands are likely to grow rapidly and that the forest, range, and inland water resources will be of increasing importance to the society and the economy.

Wildlife and Fish

All of the 1.6 billion acres of forest and range land and inland waters are used as habitat by various forms of wildlife. The Alaska barrens, for example, provide range for caribou and support for numerous kinds of smaller mammals and birds. The marshes, muskeg, and river deltas are summer nesting areas for millions of migratory waterfowl, and the streams and rivers are the spawning areas for much of the North Pacific salmon fishery.

In the contiguous States, the forest and range lands and inland waters provide habitat for more than 5 million big game animals such as deer, bear, elk, bighorn sheep, mountain goat, and moose. They also provide habitat for countless numbers of lesser mammals, songbirds, upland game birds, water fowl, reptiles, amphibians, and fish.

Among the hundreds of kinds of mammals, birds, fishes, reptiles, and amphibians that live on forest and range lands, and the associated inland waters, 143 are listed as endangered or threatened by the U.S. Fish and Wildlife Service as of November 1975.

Courtesy Bureau of Sport Fisheries and Wildlife

The black-footed ferret—one of the 143 endangered or threatened species.

Nearly all of the ecosystems in the contiguous States provide habitat for one or more of these species. There is some concentration in terms of numbers of species on the rangeland systems, and partic-

ularly those on which grass is the dominant form of vegetation.

Wildlife refuges.—In recognition of the habitat needs of wildlife, 33.5 million acres of forest and range land and inland water have been established as National Wildlife Refuges. Some 20 million acres or three-fifths of the total area in Refuges is in Alaska. As shown in figure 7, the Refuges in the contiguous States are widely distributed although there is some concentration in the Pacific Northwest, the North Central (particularly North Dakota), and Southeast and in terms of numbers along the Atlantic Coast of the Northeast.

In 1974, there were 373 units in the Refuge System. Although these Refuges provide protection for many types of wildlife, they play an especially important role in management of the international migratory waterfowl resource. Three-fourths of all Refuges were established originally for this purpose. Since 1934, most of the Waterfowl Refuges have been purchased with funds derived from the sale of migratory bird hunting stamps.

A number of Refuges are well known for providing habitat for threatened and endangered species. Among these are, the Aransas Refuge in Texas which is the principal winter home of the whooping crane, and the Red Rock Lakes Refuge in Montana, which is a nesting area for the trumpeter swan. Others include the Key Deer Refuge in Florida, established for the smallest deer in the United States; the Cabeza Prieta and Kofa Game Ranges in Arizona and the Desert Wildlife Range in Nevada, designated for the protection of the desert bighorn sheep; and the Hawaiian Islands Refuge, an irreplaceable nesting site for albatrosses and other oceanic birds, and primary habitat for the Laysan duck, Laysan and Nihoa finches, Nigoa Millerbird, and Hawaiian Mond seal.

More than 2 million public visits are made to National Wildlife Refuges annually. Wildlife associated recreation use is permitted when the activities do not interfere with the primary wildlife management program. Wildlife trails, interpretive centers, and other facilities are provided for the use and enjoyment of visitors. Fishing is permitted in many Refuge waters. Hunting of migratory game birds and resident species of game is also recognized as a valid use on many refuges. These uses are permitted in accordance with State and Federal regulations. Properly managed hunting regulates populations and distributes wildlife while maintaining a balance between populations and their food supplies.

Water

Forest and range lands are the source of most of the water in the Nation's streams, lakes, reservoirs, and ponds. However, because of differences in rainfall and other climatic conditions, there are wide regional variations in the contribution of these lands to water supplies. Some of the rangelands in the arid regions of the West, for example, are deficit areas dependent upon streams originating in mountainous forest lands for water. Other lands such as those in forests on the western slopes of the Cascade and Coast Ranges are surplus areas with hugh amounts of runoff.

Forest and range lands also influence water quality. Many sparsely vegetated ecosystems, such as those in the more arid regions of the West, are major contributors of sediment to streams and reservoirs. In contrast, the heavily vegetated ecosystems of more humid regions act to reduce erosion and the associated sedimentation, stabilize stream flows, and lower the severity and incidence of downstream floods.

In recognition of the effectiveness of vegetation in stopping erosion, reducing sedimentation, and stabilizing stream flows, several million acres of forest and range land are in watershed protection areas. On these areas, mostly watersheds used as a source of municipal water supplies, other uses such as recreation, grazing, or timber production are carefully controlled or prohibited.

Wild and scenic rivers.—Some of the Nation's inland streams and closely associated lands are used for special purposes. For example, The Wild and Scenic Rivers Act of 1968 established a National Wild and Scenic Rivers System to be composed of free-flowing streams which possess outstanding scenic, recreational, geological, fish and wildlife, historic, cultural, or other similar values.

Three classes of river areas have been identified for inclusion in the System. First, are the Wild Rivers—those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with essentially primitive watersheds or shorelines and unpolluted waters. These represent vestiges of primitive America. Second, there are Scenic Rivers—rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads. Third, there are Recreational Rivers—rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past. The units in the system must be at least 25 miles long.

The Wild and Scenic Rivers Act of 1968 designated eight rivers as initial components of the System to be administered by the Department of Agriculture and the Department of Interior. Some 56 rivers or portions have been included for study for possible wild river status. Figure 8 shows the current system and proposed additions.


NATIONAL WILDLIFE REFUGES
LEGEND
WILDLIFE REFUGE
BIG GAME REFUGE
GAME RANGE
WILDLIFE RANGE
JUNE 30, 1974

Figure 7

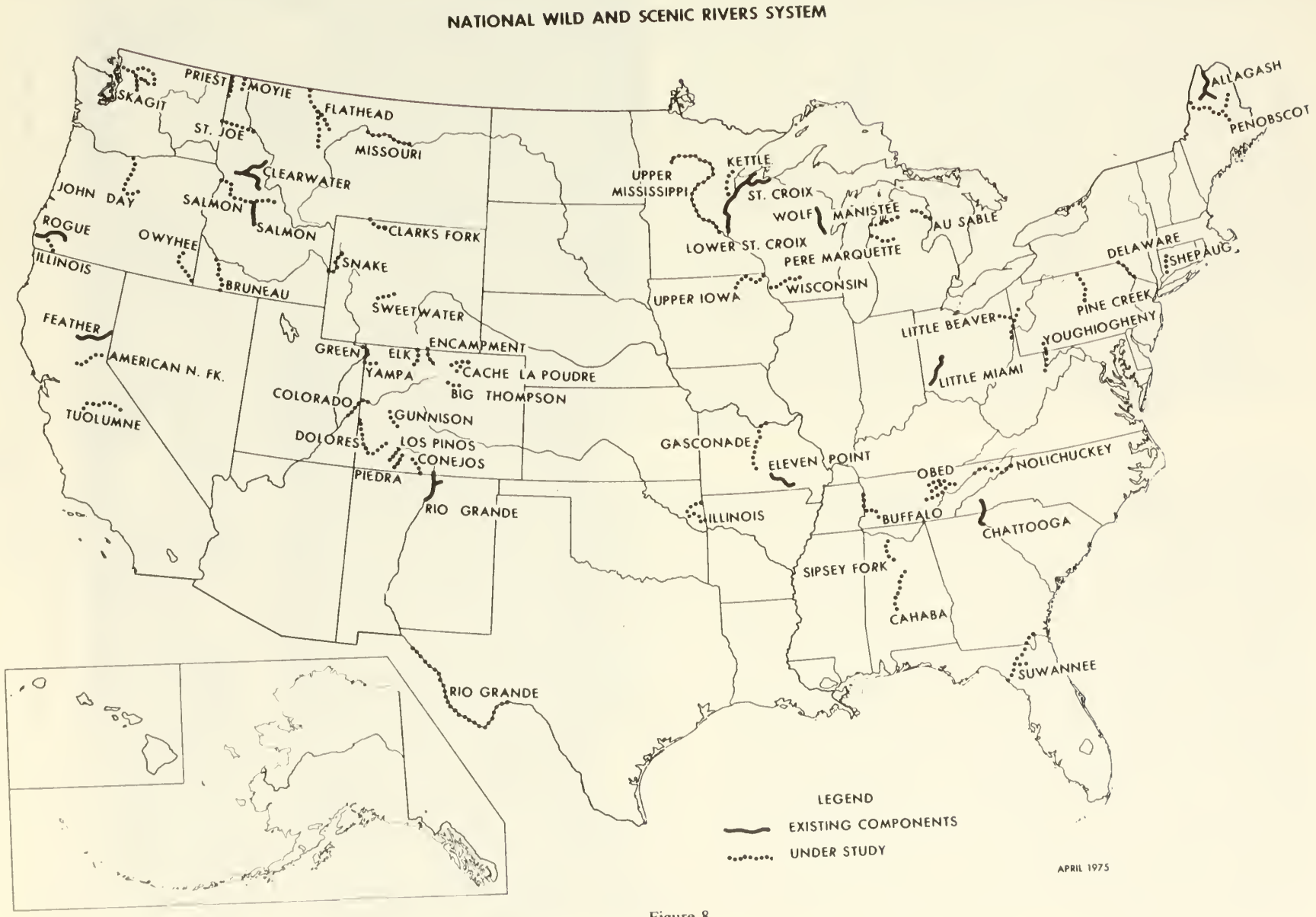
NATIONAL WILD AND SCENIC RIVERS SYSTEM
SKAGIT
PRIEST
MOYIE
FLATHEAD
ST. JOE
MISSOURI
CLEARWATER
JOHN DAY
SALMON
SALMON
ROGUE
OWYHEE
CLARKS FORK
SNAKE
ILLINOIS
BRUNEAU
SWEETWATER
FEATHER
AMERICAN N. FK.
GREEN
ELK
ENCAMPMENT
YAMPA
CACHE LA POUDRE
BIG THOMPSON
COLORADO
TUOLUMNE
GUNNISON
DOLORES
LOS PINOS
CONEJOS
PIEDRA
RIO GRANDE
RIO GRANDE
UPPER MISSISSIPPI
KETTLE
ST. CROIX
WOLF
MANISTEE
AU SABLE
LOWER ST. CROIX
PERE MARQUETTE
UPPER IOWA
WISCONSIN
ILLINOIS
GASCONADE
ELEVEN POINT
BUFFALO
OBED
NOLICHUCKEY
CHATTOOGA
SIPSEY FORK
CAHABA
SUWANNEE
ALLAGASH
PENOBSCOT
DELAWARE
SHEPAUG
PINE CREEK
LITTLE BEAVER
YOUGHIOGHENY
LITTLE MIAMI
LEGEND
EXISTING COMPONENTS
UNDER STUDY
APRIL 1975

Figure 8

The land along the Wild and Scenic Rivers Systems is generally forested with mixed cover, characteristic of geologically youthful streams. In the East, the forests associated with these rivers vary from the pine, spruce-fir, and birch-aspen of the Allagash to the oak-hickory stands mixed with elm, ash, and cottonwood on wet sites, along the Eleven Points in Missouri. In the West, coniferous stands—subalpine spruce-fir in the high country with Douglas-fir and lodgepole and ponderosa at lower elevations—cover the stream margins and facing slopes. In the East, the lands are in both private and public ownerships. In the West, the land is largely Federal.

Land withdrawal for the Wild and Scenic Rivers Systems is usually about a half mile wide or about 35,000 acres on the average for each river. As a result, the total acreage involved in all present and proposed systems is small and represents a relatively small part of the total forest and range land acreage.

The Wild and Scenic Rivers Act provides for State and local governments to select and administer river areas. Legislation has been enacted in 24 States to establish State scenic river systems, and others are considering legislation to protect and preserve free-flowing rivers. As of 1970, some 502 rivers were identified as candidates for the system by the States that have initiated action to establish State scenic river systems.

Outdoor Recreation

Nearly all of the 1.6 billion acres of forest, range land, and inland water is used in some way for outdoor recreation. The intensity and kind of use varies widely—from an occasional hunter or fisherman on the barrens and grasslands of Alaska to extremely high intensity use, common in areas of great scenic beauty, such as Yosemite National Park or developed recreational sites such as a major ski area.

Although not precise, the available data suggest that well over half of the population of the Nation participates in some form of outdoor recreation on forest and range land and inland waters each year. The economic activities associated with this recreation are important sources of employment and income, much of it in rural areas where other opportunities are limited.

Parks.—Outdoor recreation is the primary use on part of the Nation's forest and range land. A substantial portion of this area, over 30 million acres, is in the National Park System.

Although outdoor recreation is a primary use, the System serves varied educational and scientific purposes and includes four major categories of areas: historical, natural, recreational, and cultural. About half of the land in the System is in National Parks with another 10 million acres in National Monu-

F-514762

Nearly all of the 1.6 billion acres of forest and range land and inland water is used for outdoor recreation. In some places the intensity of use is very high.

ments. Other smaller areas of significance are the Historic Parks; Battle Fields and Military Sites; National Recreation Areas including Seashores, Lakeshores, Parkways, Rivers, and Trails; and the cultural areas such as Wold Trap Farm Park near Washington, D. C. All of the areas have been established by congressional action, with the exception of a few National Monuments which were established by executive orders authorized by the Antiquities Act of 1906.

As illustrated in figure 9, the National Park System is widely distributed geographically although in terms of acreage there is some concentration in the Southwest, Rocky Mountain, and Pacific Coast States. Most forest and range ecosystems are represented from the arctic tundra found in Mount McKinley National Park in Alaska to the shrub systems of the Southwest and the wet grasslands of the Florida Everglades. The Parks are also geologically diverse representing many ages from the Pre-Cambrian Era characterized as "the morning of life" down through "the golden age of mammals" which extends to the present time. Landforms include coral islands, reefs, and atolls as well as the works of glaciers and volcanoes.

Generally, uses such as grazing, mining, hunting, and timber cutting are not allowed in natural and historical parks. Since over 80 percent of the land in the System is included in these two categories, the use of large land areas is restricted. This, however, does not necessarily indicate serious impacts since much of this land is inaccessible or not very productive for timber or forage.

In addition to the National Park System, substantial acreages of forest and range land are included in State park systems. State parks encompass over 3.5 million acres in general and community parks alone. Many State park agencies also administer State forests, fish and game areas, historical and cultural sites, wayside areas, and even wilderness and primitive areas. If all public outdoor recreation lands administered by States are added together, the total—over 40 million acres—exceeds that in the National Park System. Though the scenic, natural, and historical values depicted may not be of prime national significance, they are important in illustrating these values on a State level and in providing local recreational opportunities. And, since many State systems include designated forests and fish and game areas, State programs are often oriented more toward multiresource use than the National Park program.

Parks administered by local governments—counties, cities, and townships—cover almost 1.5 million acres. Although relatively small, these local parks account for about 80 percent of all the parks in the country, and provide the sites for much of the Nation's close-to-home outdoor recreation.

Trails.—In addition to Parks, an extensive trail system is being established on forest and range lands. Trails have played an important role in the past. During colonial times, they served as the chief means of travel from one place to another. They continue to play an important part in satisfying some of the growing demands for outdoor recreation.

Recognizing the importance of trails, Congress passed the National Trails System Act in 1968. The Act defined two major categories of trails; National Scenic Trails and National Recreation Trails. National Scenic Trails are extended, continuous trails selected and developed because of their superior scenic, historical, natural, or cultural qualities. National Recreation Trails vary in length but must also be continuous and are generally located close to urban areas to provide easy access to a variety of outdoor recreation uses.

Figure 10 shows the two National Scenic Trails designated by Congress and the others being studied. The Appalachian Trail, established in the East, extends approximately 2,000 miles through 14 States from Maine to Georgia. This trail is diverse in almost every respect. It reaches a height of 6,641 feet in the Great Smokies, and dips close to sea level where it crosses the Hudson River. The trail passes through forests which vary from the spruce-fir type of the Northern coniferous forest to beech-birch-maple to oak-hickory and oak-pine type near its southern extremity. It crosses a variety of ownerships, including 960 miles of Federal land, 302 miles of State land, and 771 miles of private land.

By contrast, the Pacific Crest Trail primarily crosses Federal lands including 22 National Forests and 6 National Parks. Of this 2,458-mile trail, extending from the Mexican to the Canadian borders, only 43 miles are State-owned and 346 are in private ownerships. It is, however, more diverse in its physical and vegetative characteristics than the Appalachian Trail. It passes through glacial moraines and icefields, lava flows, and basalt columns. Its cover includes Alpine spruce-fir forests; Douglas-fir, lodge-pole, and ponderosa pine at lower elevations; as well as the fragile cover characteristic of desert landscapes and wind-swept mountaintops.

In addition to these two established trails, two others are in late stages of review. Legislation on the Potomac Heritage Trail is currently before Congress. This 874-mile trail extending from the mouth of the Potomac to its source in Pennsylvania and West Virginia will add a new dimension to the present National Scenic Trail system. It includes the 185 mile Chesapeake and Ohio Canal towpath and will focus on an outstanding array of historic, scenic, natural, and cultural features. The 3,100-mile Continental Divide Trail is also far along in the study process and is currently being reviewed by the Office of

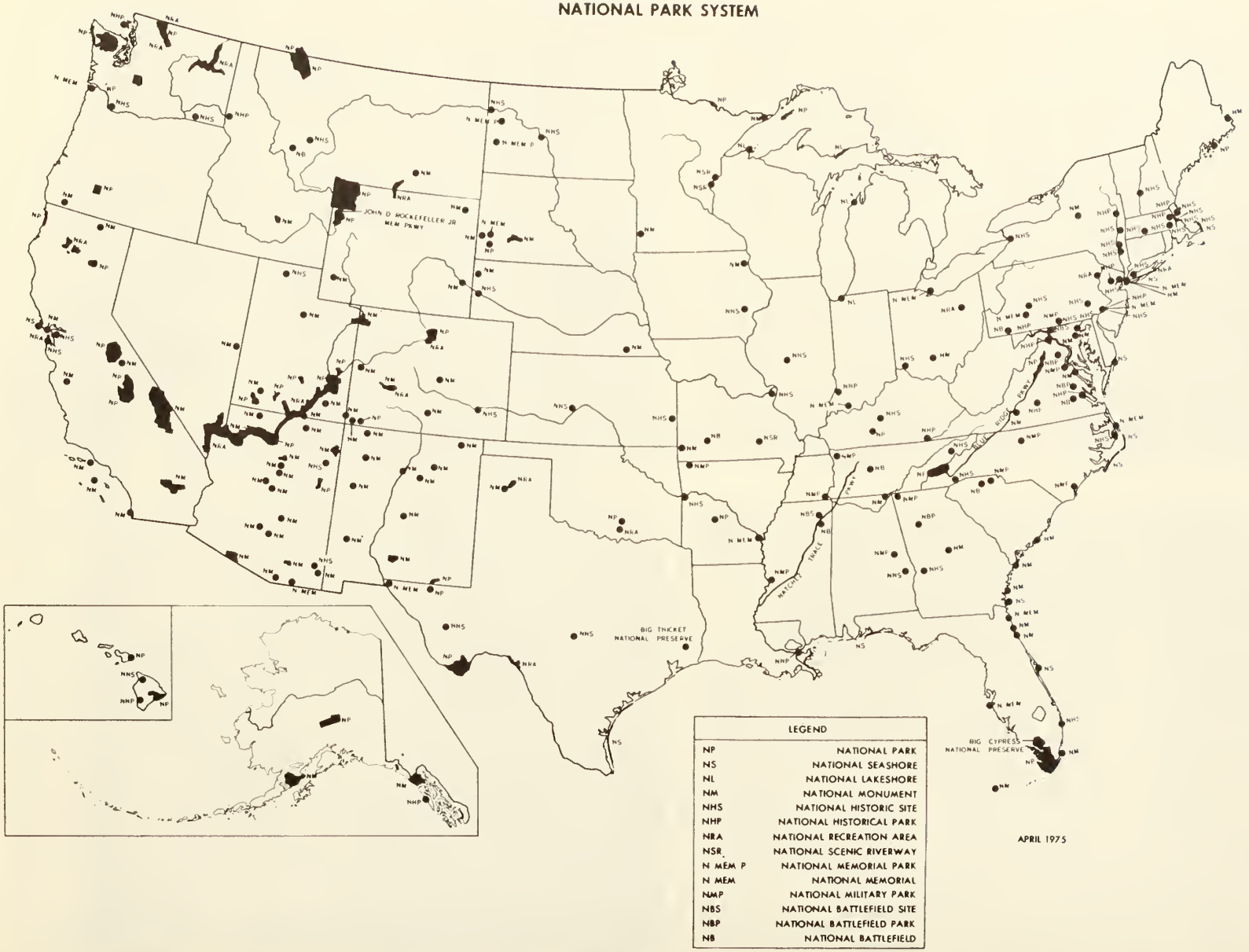
NATIONAL PARK SYSTEM
JOHN D ROCKEFELLER JR MEM PKWY
BIG THICKET NATIONAL PRESERVE
NATCHEZ TRACE PKWY
BLUE RIDGE PKWY
BIG CYPRESS NATIONAL PRESERVE
LEGEND
NP NATIONAL PARK
NS NATIONAL SEASHORE
NL NATIONAL LAKESHORE
NM NATIONAL MONUMENT
NHS NATIONAL HISTORIC SITE
NHP NATIONAL HISTORICAL PARK
NRA NATIONAL RECREATION AREA
NSR NATIONAL SCENIC RIVERWAY
N MEM P NATIONAL MEMORIAL PARK
N MEM NATIONAL MEMORIAL
NMP NATIONAL MILITARY PARK
NBS NATIONAL BATTLEFIELD SITE
NBP NATIONAL BATTLEFIELD PARK
NB NATIONAL BATTLEFIELD
APRIL 1975

Figure 9

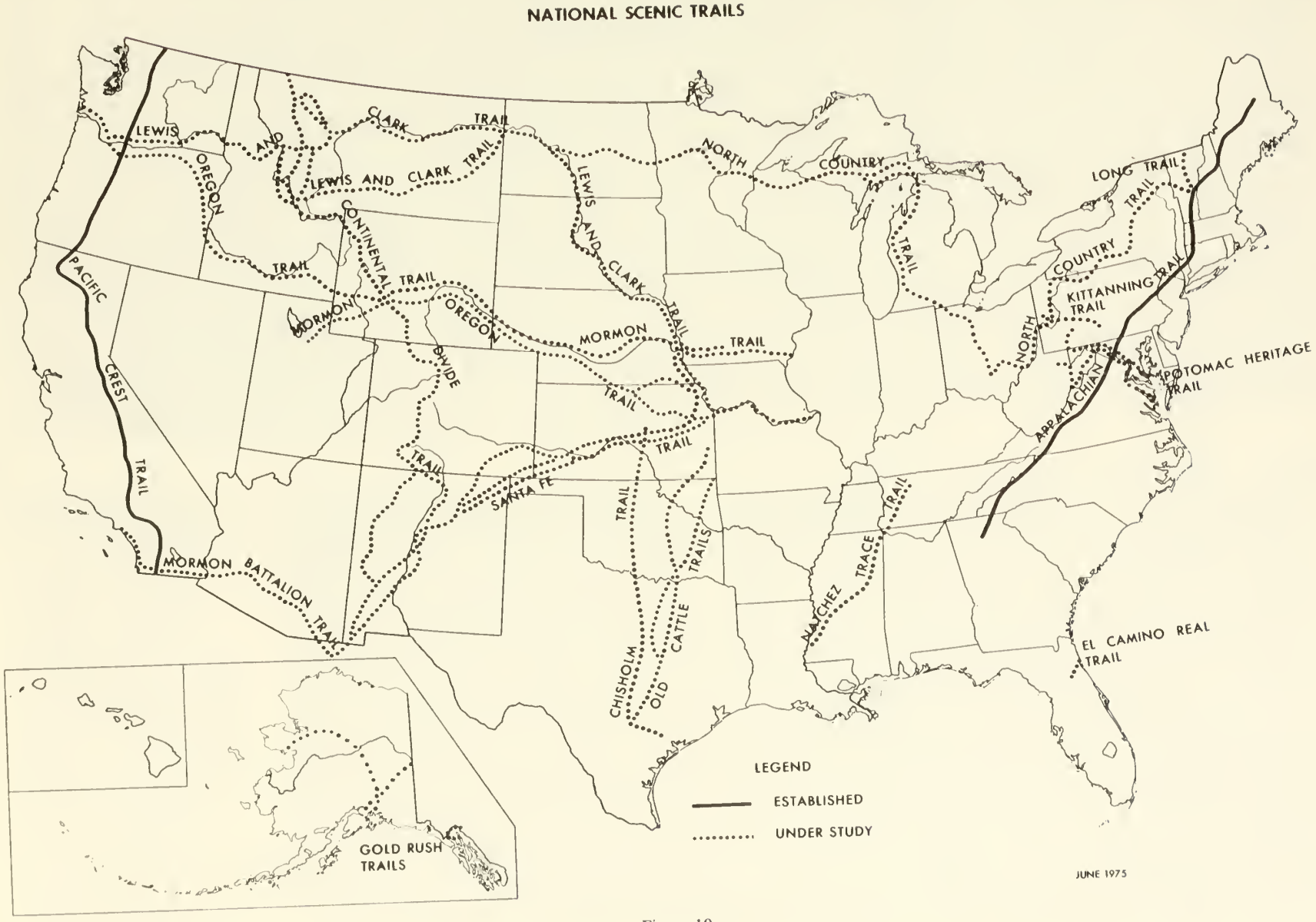
NATIONAL SCENIC TRAILS
LEWIS AND CLARK TRAIL
OREGON TRAIL
CONTINENTAL DIVIDE TRAIL
LEWIS AND CLARK TRAIL
NORTH COUNTRY TRAIL
LONG TRAIL
COUNTRY TRAIL
KITTANNING TRAIL
NORTH APPALACHIAN TRAIL
POTOMAC HERITAGE TRAIL
PACIFIC CREST TRAIL
MORMON TRAIL
OREGON TRAIL
MORMON TRAIL
SANTA FE TRAIL
OLD CATTLE TRAILS
CHISHOLM TRAIL
NATCHEZ TRACE TRAIL
EL CAMINO REAL TRAIL
MORMON BATTALION TRAIL
GOLD RUSH TRAILS
LEGEND
ESTABLISHED
UNDER STUDY
JUNE 1975

Figure 10

Management and Budget. It will stretch from southwestern New Mexico to Glacier National Park near the Canadian border. Its many miles above timberline offer spectacular views of Alpine wilderness.

Whereas National Scenic Trails are routed to avoid highways, power lines, and commercial and industrial developments and often afford more primitive experiences, National Recreation Trails are located so they are available to the greatest number of people. Possible locations include utility rights-of way, areas around reservoirs, and easements for underground cables. Also, congressional action is not required to establish National Recreation Trails which may be designated by the Secretaries of the Interior or Agriculture acting with the consent of the agency or political subdivision having jurisdiction over trail land. Presently, 79 National Recreation trails have been established in 30 States on a variety of ownerships and others are being considered for inclusion (fig. 10). They range in length from less than a quarter of a mile to 67 miles and are associated with lands varying in cover from that typical of city parks to unmanaged natural forest areas. They also add a new dimension since they include trails for the handicapped—like the braille Touch of Nature Trail operated by the Maryland Park Commission—and since they may be planned for bicycle, trail bike, snowmobile, or other use.

The 1968 Act is particularly comprehensive in that it directed the Secretary of the Interior to encourage States to consider the need for trails as State outdoor recreation plans are made. The Secretary of the Interior is also directed to encourage the establishment of trails on State, county, municipal, and private lands. Funds are available from the Land and Water Conservation Fund for this purpose. Currently, trail systems totaling over 136,000 miles exist in all 50 States, many of them owing their origins to the Civilian Conservation Corps of the 1930's. Most States plan additional trails and many have enacted specific trail legislation with 33 States considering State trail systems in their Statewide Comprehensive Outdoor Recreation Plan. States having several thousand miles of trails include: California, Colorado, Idaho, Michigan, Montana, New York, Oregon, Pennsylvania, Utah, Vermont, Washington, and Wyoming.

Wilderness

Outdoor recreation is also a major use of wilderness areas. The first wilderness area—a half million acres in the headwaters of the Gila River on the Gila National Forest in New Mexico—was set aside in 1924 by the Secretary of Agriculture in response to a proposal by Aldo Leopold. Other areas were soon added and by 1940 the system comprised 73 areas.

Various groups sought more permanence in wilderness designations by proposing Federal legislation to establish a national wilderness system. In response to this interest, Congress passed the "Wilderness Act" in 1964 which established a National Wilderness Preservation System composed of Federally owned lands designated as "wilderness areas."

The 1964 Act required all of the areas which had been classified under the Secretary of Agriculture Regulations as wilderness, wild, or canoe areas to be designated as wilderness areas. The legislation directed the Forest Service to review all National Forest areas classified as "primitive" and make recommendations to the President and Congress within 10 years as to their suitability for preservation in the national wilderness system. The Secretary of the Interior was directed to review every roadless area of 5,000 contiguous acres or more in the National Parks, National Monuments, and National Wildlife Refuges for possible inclusion in the National Wilderness Preservation System.

In 1975, a Congressional Act, (P. 93–622) established 16 Wildernesses in the East with a total area of about 171,000 acres east of the 100th meridian. This Act also designated 17 additional areas to be studied for possible inclusion into the National Wilderness Preservation System. The 17 areas cover approximately 125,000 acres. The Act requires that the studies be complete and a report made to Congress within 5 years on their suitability. Congress has also passed legislation requiring the study of 6 specific areas totaling 700,000 acres in the West.

As of July 1975, there were 125 Federal Wildernesses areas containing 12.3 million acres (fig. 11). Reviews are complete and awaiting Congressional action for 112 areas containing 26.1 million acres.

As a result of past land development patterns, (or, more precisely, the lack of development) the designated Wilderness areas, and those under review and study, are concentrated in western States and Alaska. However, lands within the system include areas from nearly all of the major forest and range land ecosystems represented in the United States.

In addition to outdoor recreation, Wildernesses provide habitat for countless numbers of wildlife and many of the rare and endangered species. The undisturbed vegetation also protects the headwaters of many of the major streams and rivers in the West, and provides undisturbed areas (vegetation, wildlife, soils, etc.) for scientific study. However, the Wilderness Act generally precludes the use of Wilderness for commodity production. Timber may not be harvested, water developments are prohibited (except by special approval of the President), and the right to file new mineral claims will end in 1984.

As a result of the limitations on use, the reservation of forest and range land for Wilderness does

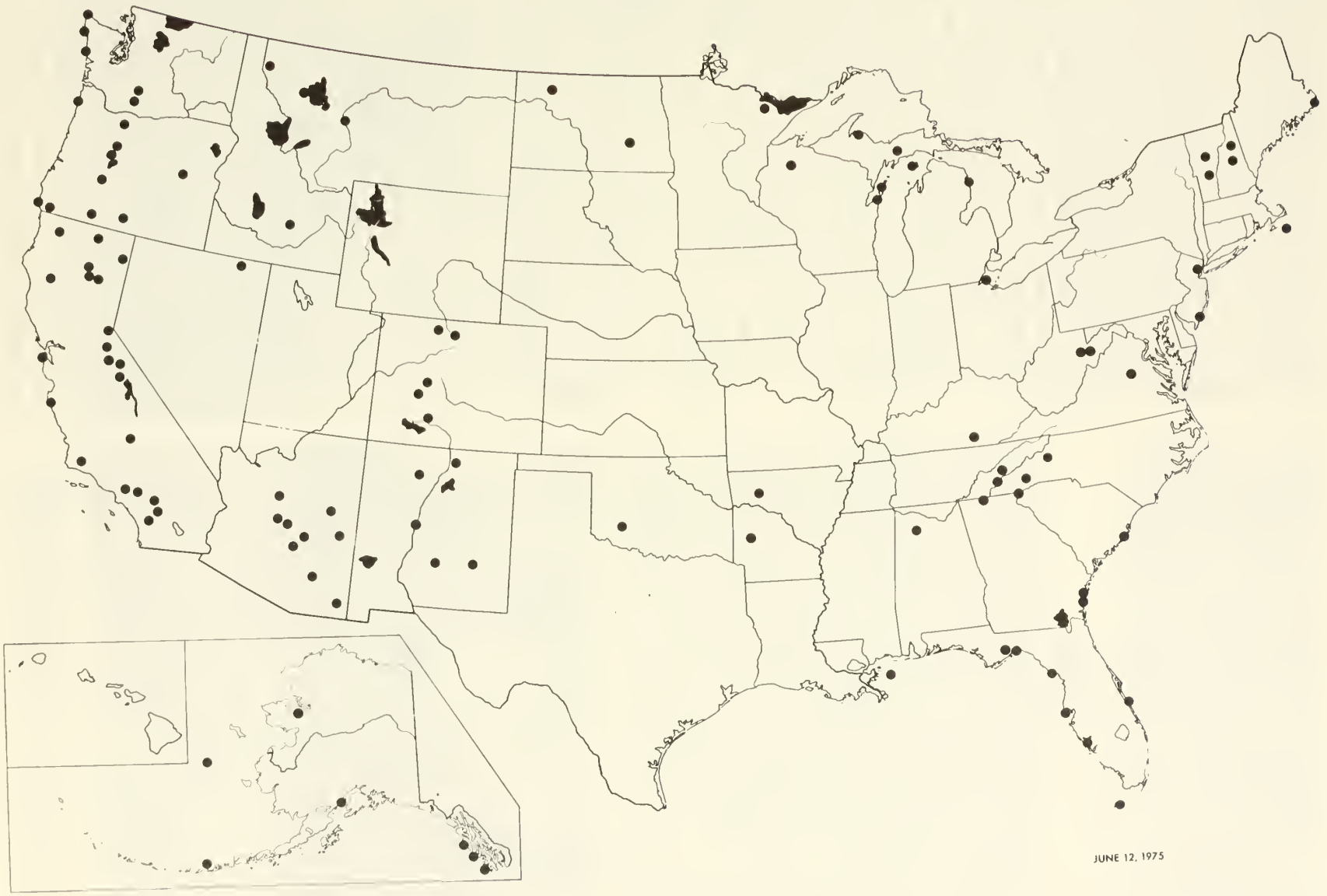

Figure 11

have impacts on the production of some commodities. It is estimated that present Wildernesses include about 6.7 million acres that meet the minimum standards for commercial timberland. The sawtimber inventory on these lands is estimated at 58.2 billion board feet with a potential allowable harvest of 0.9 billion board feet. In addition, many opportunities exist for water retention and for the development of quality recreation areas. Wildernesses also may contain valuable mineral deposits.

Grazing

The bulk of the Nation's forest and range land produces vegetation suitable for grazing by domestic livestock. However, because of climate, inaccessibility, and use for other purposes, only about two-thirds of the total—835 million acres—is grazed. Nearly all of this area is in the contiguous States.

Most of the area grazed is in the Western States. Approximately 419 million acres with native grass or shrub cover is in the 11 Western States. Another 229 million acres, nearly all grasslands, is in the Great Plains States. The rest of the land grazed is forested. Grazing on forest ecosystems is largely on the open pine and hardwood forests of the West and the pine forests of the South. Livestock grazing also occurs in eastern hardwood forest ecosystems, and some of this is at the expense of other resource values.

Of the 835 million acres of forests and ranges grazed, 68 percent is in non-Federal ownership and these non-Federal forests and ranges produce about 86 percent of the livestock grazing. Lands in Federal ownership make up 32 percent of the land grazed and produce about 14 percent of the livestock grazing.

F-497887

The bulk of the forest and range land produces vegetation suitable for grazing by domestic livestock.

About three-fourths of the grazed land in the lower 48 States in 1970 was managed for livestock at extensive levels. Maximizing for livestock production occurred on about 50 million acres and was concentrated in the Prairie, Plains, and Mountain grassland systems. Some 72 million acres of the Eastern Forests were grazed exploitatively, i.e., grazed in such a manner that soil and vegetation were depleted.

It was estimated that the forest-range land ecosystems provided about 213 million animal unit months of grazing in 1970. While this output was spread nationwide, 70 percent came from the western rangeland ecosystems. Most production was on non-Federal lands. A measure of the dollar value of this grazing is the sales value of livestock gains made on the range. The value of the livestock gains in 1970 was estimated at $1.7 billion, almost equal to the farm value of the wheat crop in that year.

In addition to grazing values, range offers habitat and forage for numerous species of wildlife. In fact, most range evolved while supporting herbivorous animals such as the buffalo, elk, deer, and antelope. Game birds, hawks, eagles, and a host of song birds, as well as other kinds of wildlife, find homes on range. Many streams important to the production of fishes flow through range and have headwaters that are important spawning grounds for anadromous fish.

Range, especially at higher elevations in the West, is an important source of water used for irrigated crop production. Range in good condition also serves to store water for sustained flow throughout the summer dry seasons in the Intermountain West.

In recent years, the recreational values of range have been recognized, and many thousands of hikers or horseback riders annually travel through range areas as part of their vacation experience. Many working cattle ranches in the West, that derive much of their income from livestock grazed on range, open their ranches to the public on a paying basis to observe and experience range-ranching.

Timber

As indicated above, about 500 million acres, or nearly a third of the forest and range land base, is classified as commercial timberland suitable for the production of crops of industrial timber products. In 1970, the roundwood output from these lands was 11.6 billion cubic feet. Another 1.6 billion cubic feet was cut and left in the forests as logging residues, and 1.3 billion cubic feet was removed in land clear-

ing operations or reserved on areas withdrawn from commercial use.

In addition to the roundwood obtained from commercial timberlands, 0.6 billion cubic feet was harvested from forested lands classified as noncommercial. Total roundwood timber production in 1970 thus amounted to 12.2 billion cubic feet.

The total value of this timber at local points of delivery was $4.2 billion. As shown in the tabulation below, timber was the Nation's second most important agricultural crop in terms of value, equal to about 17 percent of the value of all farm crops, and substantially larger than such major crops as soybeans, wheat, and cotton.

Product	*Value at local points of delivery, 1970 (billion dollars)*
Roundwood	4.2
Farm crops:	
Corn	5.5
Soybeans	3.2
Hay	3.1
Wheat	1.9
Cotton	1.2
All other[1]	9.2
	24.1

[1] Includes 73 crops.

The roundwood produced from domestic forest plus net imports composes nearly one-fifth of all the industrial raw materials consumed in the economy. Processing of this raw material into consumer products supports thousands of industrial establishments and millions of workers, many in rural areas where timber is the principal support of the local economy.

F-53806

Logs are one of the Nation's most important agricultural crops and compose a fifth of all industrial raw materials consumed.

While of great importance to the economy, timber production is not an exclusive use of commercial timberland. All of the forest land producing timber is used for other purposes such as wildlife habitat, recreation, and/or watershed protection. Much of it also grazed by domestic livestock.

Minerals

Extensive mineral deposits underlie forest and range lands in the contiguous States and Alaska. The bulk of these deposits occur in a great mineralized belt 1,300 miles long and 300 miles wide, stretching from western North Dakota to southern Arizona.

Nearly 70 percent of the Nation's coal reserve is in this area. Most of the western coal, nearly 50 percent of total U.S. reserves, is in Wyoming, North Dakota, and Montana, nearly all under forest and range lands, mostly the latter (fig. 12). Of the 128 million acres underlain by coal in the West, 1.5 million acres are considered to be minable by surface methods. There are also extensive coal deposits in Illinois, Indiana, Kentucky, West Virginia, Pennsylvania, and Ohio. Most of the coal resources in this area underlie commercial timberlands.

The country's principal oil shale deposits that are currently considered to be exploitable are in Wyoming, Colorado, and Utah, mostly under rangelands (fig. 13). Oil shale and tar sands are also widespread west of the Appalachian Mountains, and in the southern Midwest although their development potential is presently considered low.

Much, if not most, domestic oil and gas production and potential is, except for the Outer Continental Shelf, from strata under forest and range lands.

Large deposits of phosphate also underlie forest and range lands. The phosphate deposits of the Atlantic Coastal Plain of the Southeastern States contain about 42 percent of the identified domestic phosphate resources and about 61 percent of the hypothetical resources. Other major beds are in a single geologic horizon, the Phosphoria Formation, in the Western States of Idaho, Montana, Utah, and Wyoming. These four States contain about 57 percent of the identified domestic resources and about 35 percent of the hypothetical resources.

There are deposits of uranium, iron, lead, molybdenum, and clay in the western mineralized belt described above. There are also deposits of sand, gravel, and clay in most parts of the country.

Mining of the above minerals and materials has, and will continue to have, impacts on forest and range land resources. In the period 1930–71, for example, some 3.7 million acres of lands in the United States, an average of about 90,000 acres a year,

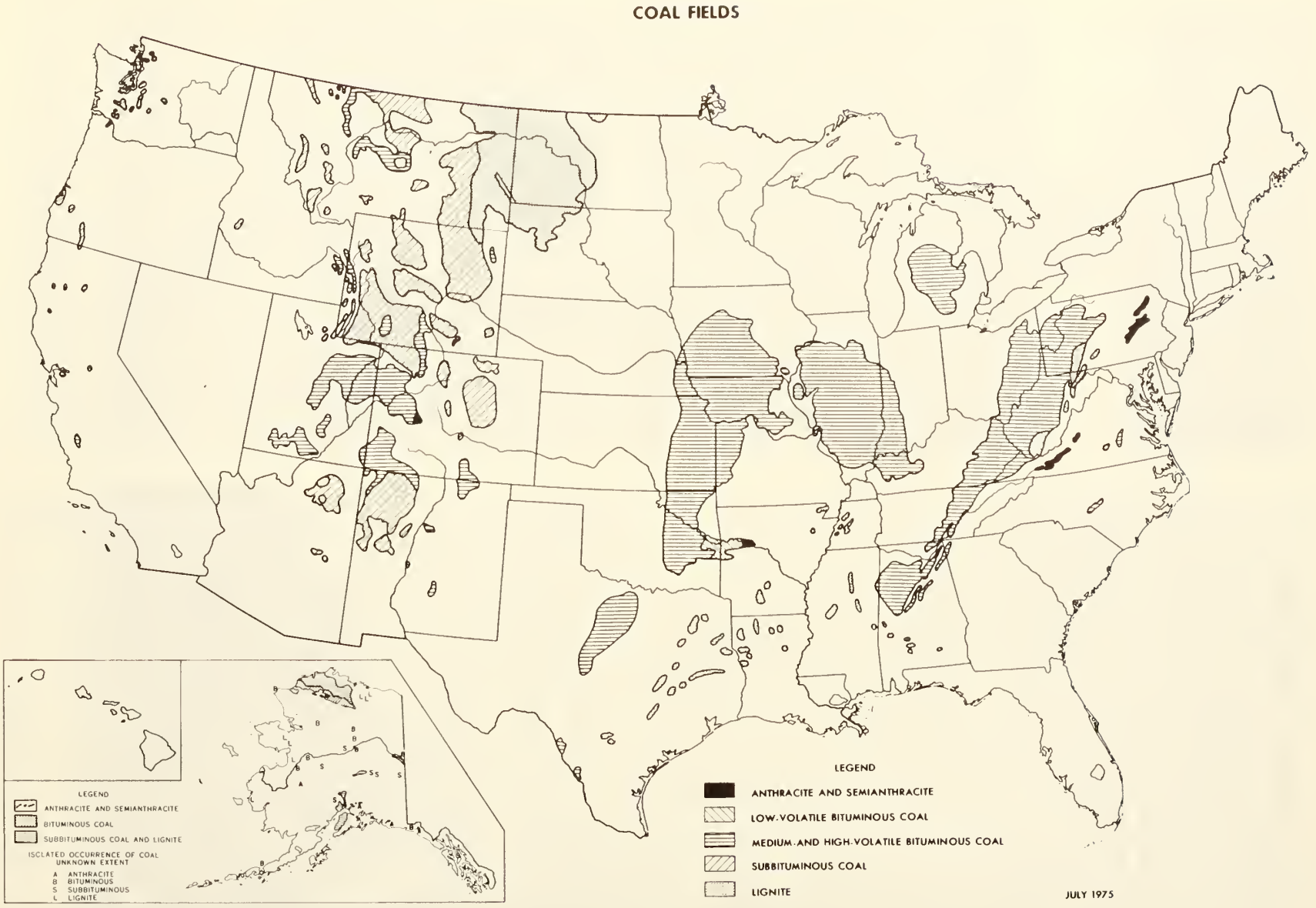
COAL FIELDS
LEGEND
ANTHRACITE AND SEMIANTHRACITE
LOW-VOLATILE BITUMINOUS COAL
MEDIUM- AND HIGH-VOLATILE BITUMINOUS COAL
SUBBITUMINOUS COAL
LIGNITE
JULY 1975
LEGEND
ANTHRACITE AND SEMIANTHRACITE
BITUMINOUS COAL
SUBBITUMINOUS COAL AND LIGNITE
ISOLATED OCCURRENCE OF COAL UNKNOWN EXTENT
A ANTHRACITE
B BITUMINOUS
S SUBBITUMINOUS
L LIGNITE

Figure 12

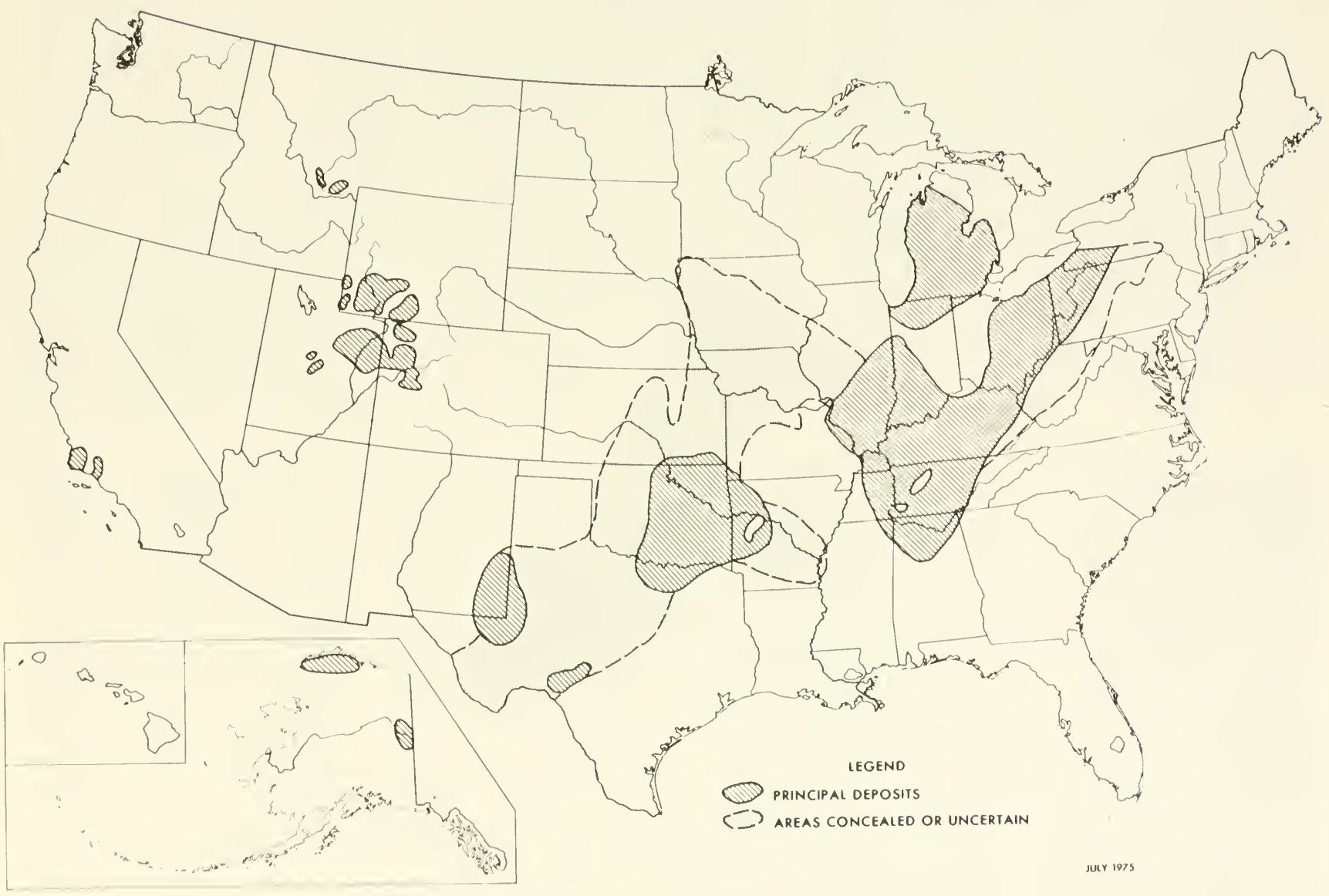
OIL SHALE DEPOSITS
LEGEND
PRINCIPAL DEPOSITS
AREAS CONCEALED OR UNCERTAIN
JULY 1975

Figure 13

were affected by mining.[7] Over the next few decades, the area disturbed may increase, particularly in those parts of the country with coal and oil shale deposits that can be mined by surface methods. This disturbance could have important local impacts. However, the area involved should continue to be small relative to the 1.6 billion acres classified as forest and range land. This, along with the extensive reclamation of disturbed land, which seems to be in prospect, should minimize impacts on the output of forest and range land products such as forage and timber.

Special Land Uses

Many lands of special or unique interest and significance lie within the forest and range lands of the Nation. Included are a diversity of natural areas, special interest areas, historic places, and primitive areas.

Authority for establishing Special Interest Areas in the National Forest System dates back to the Organic Administration Act of 1897, and more recently from the Environmental Policy Act of 1970. Generally, there are two types of Special Interest Areas: (1) Cultural—which include historic or prehistoric (archeological) sites and areas of significance and places obviously to become historic in the future, and (2) Natural—which are outstanding examples of the Nation's geological and ecological features including scenic, geological, botanical, zoological, and paleontological areas.

Almost a million acres of Forest Service lands, with almost one and one-half million visitor-days of use each year, are now included in these special interest categories. The areas are regarded as a nonrenewable and irreplaceable resource and are treated as such. The primary management objective is to maintain the basic integrity of the site. However, a wide range of uses are permitted in line with this objective and the Forest Service actively works with other organizations to maximize the scientific values of the areas.

For example, many Special Interest Areas are included in National Park Service registries of National Landmarks and National Historical Landmarks. These registries also include a variety of other areas which illustrate the diversity of the country's natural environment and American history. Participation is not limited to public agencies—places in all ownerships meeting the tests of national significance and approved by the Secretary of the Interior may be registered by their owners.

The Nature Conservancy has recently proposed a "National Registry of Ecological Reserves." One chief objective of this Registry, in addition to identifying areas of national ecological importance, would be to unify the varying preservation and management objectives and techniques now being applied by various conservation agencies. This Registry would include areas now listed in a myriad of programs at Federal, State, local, and private registries.

The Federal Committee on Ecological Reserves, formerly the Federal Committee on Research Natural Areas, is developing a system of areas maintained and reserved primarily for their scientific and educational value. Natural conditions on these areas are achieved by allowing ordinary physical and biological processes to continue without human intervention. Presently, 369 research natural areas covering almost 1.7 million acres have been classified in this manner by the Energy Research and Development Administration, Bureau of Land Management, Forest Service, Fish and Wildlife Service, National Park Service, Tennessee Valley Authority, and the Air Force.

The Bureau of Land Management identifies outstanding natural areas and primitive areas, and the Fish and Wildlife Service has authorization to acquire land to conserve endangered or threatened species. The States manage about 700 natural areas involving almost 800,000 acres and at the local level another 800,000 acres are designated natural preserves. In addition, a number of private organizations either register or own natural areas. These include the Philadelphia Conservationists, American Forestry Association, National Audubon Society, Natural Lands Trust, Inc., Society of American Foresters, Society for Range Management, and the Nature Conservancy. Though programs of these organizations are generally related, they often differ in their objectives, criteria, management, funding, and protection.

Large acreages of Indian lands are also designated or proposed as natural, primitive, or wilderness. About 200,000 acres are designated, specifically, in this fashion on Indian reservations and a total of over 6 million acres of these lands are given to public recreation in general.

Generally, most of the lands in special interest categories are restricted to nonconsumptive uses which do not impair their essential values. The impacts of the restrictions are not easy to assess because much of these lands, such as some of the Research National Areas, have low commercial value and many others are not suitable for other uses. Even in those cases where alternative consumptive uses are possible, alternative uses are seldom so important as to outweigh the unusual and significant special interest values.

[7] Includes areas disturbed by excavation; disposal of mine, mill, and processing wastes; and underground workings. Land utilization and reclamation in the mining industry, 1930–71. U.S. Department of the Interior, Bureau of Mines. Info. Bull. No. 8642. 1974.

Summary

In summary, it is clear that all of the Nation's forest and range land, and the associated inland waters, are used for more than one purpose. Even those lands—such as National Recreation Areas where a primary use is designated—also provide habitat for wildlife, water, and watershed protection. Wilderness areas are used in prescribed ways for commercial purposes such as grazing and mining. Commercial timberland and rangeland are used for multiple purposes—in the case of National Forest System lands by the direction of Congress (The Multiple-Use Sustained Yield Act of 1960).

Up to a point, forest and range lands can be used for multiple purposes without significant impacts on individual uses. However, there are limits and this has become increasingly evident in the past few decades as the demands for forest and range products have grown rapidly. The limits are clearest where areas are designated or set aside for some primary or dominant use such as recreation, wildlife refuges, or wilderness. This type of use does have direct and important impacts on the use of the land for other purposes.

In the following chapters of this study, projections of demands for outdoor recreation and wilderness, wildlife and fish, range grazing, timber, and water are presented. These projections provide a measure of how demand is likely to grow if the assumptions on population, economic activity, energy costs, technological and institutional changes, and other determinants are realized.

Information in these chapters also shows that there are many opportunities to increase, extend, and improve supplies of all products. For example, under intensive management, the Nation's commercial timberlands have the capability of producing at least twice the volume of timber grown today. And this could be done while maintaining the forest environment and increasing the output of other products.

But inevitably, the point will be reached where increasing the output of one product will constrain or reduce the output of another. Thus, attempts to increase production from forest, range land, and inland water, and to use areas for special purposes, will mean increasing conflicts among users. The resolution of these conflicts in a way which will optimize the use of forest, range, and water resources will be a growing challenge to public and private managers in the decades ahead.

Outdoor Recreation and Wilderness

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Outdoor recreation on forest and range land has grown rapidly. This has led to overcrowding at many popular areas.

This chapter presents information on (1) trends in the use of developed site and dispersed outdoor recreation with projections of demand to 2020, (2) recent changes in supply of outdoor recreational facilities, and (3) opportunities for improving forest and range land and the associated inland waters for outdoor recreation activities. It also includes a discussion of the use of forest and range land as Wilderness.

Outdoor Recreation

For millions of Americans, outdoor recreation is an important activity enjoyed on the Nation's forest and range lands and inland waters. Outdoor recreation use has increased rapidly during the last several decades, mostly since 1950. Many factors are responsible, but they all relate to increased growth in population; a higher standard of living for much of the population; and related factors such as the age distribution of the population, increased mobility, more leisure time, better access to recreation areas, and better information for the recreationist about where to go and what to do in the out-of-doors.

Along with the benefits to the user, however, have come some negative consequences. Increased use of recreation areas has led to overcrowding of the more popular sites, and in some cases has had an adverse impact on other important uses of the forest and range lands and inland waters.

Participation in Outdoor Recreation

At the present time, there are no national data that relate outdoor recreation use exclusively to forest and range lands and inland waters. But insights can be gained from a 1972 Bureau of Outdoor Recreation survey[1] and from the yearly reports of the Forest Service and National Park Service.

[1] U.S. Department of the Interior, Bureau of Outdoor Recreation. Outdoor recreation: a legacy for America—Appendix "A": an economic analysis. Government Printing Office, Washington, D.C. 239 p. 1973.

Table 13. *Participation in outdoor recreation in the contiguous States, by type of activity and time of participation, summer 1972*

Type of activity	Millions of activity days of participation	Percent of survey respondents who participated	Percent of activity which occurred on weekends
Picnicking	405.1	47	71
Sightseeing	362.8	37	62
Wildlife and bird photography	19.6	2	56
Birdwatching	42.0	4	75
Walking for pleasure	496.3	34	64
Nature walks	148.9	17	70
Hiking with a pack, mountain and rock climbing	45.0	5	62
Driving for pleasure	404.9	34	(1)
Driving 4-wheel vehicles off road	26.6	2	56
Riding motorcycles off the road	58.2	5	62
Horseback riding	51.5	5	51
Bicycling	214.2	10	69
Hunting	17.5	3	64
Fishing	278.2	24	68
Outdoor pool swimming	257.0	18	52
Other swimming outdoors	487.1	34	69
Golf	63.4	5	51
Tennis	81.2	5	79
Water skiing	54.1	5	69
Canoeing	18.3	3	72
Sailing	32.5	3	75
Other boating	126.1	15	74
Camping in developed campgrounds	153.3	11	62
Camping in remote or wilderness areas	57.5	5	80
Visiting zoos, fairs, amusement parks	122.5	24	55
Going to outdoor concerts, plays etc.	26.5	7	66
Going to outdoor sports events	96.9	12	57
Playing other outdoor games and sports	338.8	22	65
Other activities	242.9	24	(1)

[1] Was not compiled.

Source: U.S. Department of the Interior, Bureau of Outdoor Recreation. *Outdoor recreation: a legacy for America—Appendix "A" an economic analysis.* Government Printing Office, Washington, D.C. 239 p. 1973.

The 1972 Bureau of Outdoor Recreation survey covered summer activities and consisted of personal interviews with members of 4,029 randomly selected households distributed throughout the contiguous States. The focus of the survey was on what people said they did, rather than on preferences, attitudes, or psychological aspects of the recreation experience.

As in previous surveys, the activities people said they preferred most were picnicking, sightseeing, swimming, driving for pleasure, and walking for pleasure (table 13). More than half of the reported participation for all activities took place on weekends but this pattern was not quite as pronounced for recreation on National Forest and National Park lands. Forty-five percent of the reported participa-

Table 14. *Characteristics of participants in outdoor recreation in the contiguous States, summer 1973*

Characteristics	Percent of outdoor recreation participants				Percent U.S. population age 12 and over
	National Forests	National Parks and Monuments	Other Federal lands	All other lands	
Age:					
12–17	15.7	10.2	18.5	25.2	15.3
18–24	22.9	21.7	20.6	20.9	15.4
25–44	35.4	38.6	40.3	33.2	30.4
45–64	22.9	22.9	16.8	17.3	26.0
Over 65	3.1	6.6	3.8	3.4	12.9
	100.0	100.0	100.0	100.0	100.0
Sex:					
Men	65.6	58.4	55.4	52.6	48.0
Women	34.4	41.6	44.6	47.4	52.0
	100.0	100.0	100.0	100.0	100.0
Place of residence:					
Not in SMSA[1]	24.0	39.8	50.0	34.5	31.0
In SMSA	76.0	60.2	50.0	65.5	69.0
	100.0	100.0	100.0	100.0	100.0
Family income:					
Under $3,000	6.7	7.2	6.5	5.8	15.0
$3,000–$5,999	15.1	14.5	17.4	10.2	17.6
$6,000–$7,999	10.9	14.5	17.4	14.1	12.0
$8,000–$9,999	16.7	13.2	19.7	15.0	11.7
$10,000–$14,999	24.5	29.5	22.8	27.9	22.6
$15,000–$24,999	19.8	15.1	13.0	19.0	15.7
$25,000 & over	6.3	6.0	3.2	8.0	5.4
	100.0	100.0	100.0	100.0	100.0
Race:					
White	92.7	93.8	95.1	89.9	87.7
Nonwhite	7.3	6.2	4.9	10.1	12.3
	100.0	100.0	100.0	100.0	100.0
Census region:					
Northeast	20.8	10.2	12.5	24.0	24.9
North Central	19.8	21.7	33.7	29.4	28.1
South	27.6	14.5	33.7	26.3	30.4
West	31.8	53.6	20.1	20.3	16.7
	100.0	100.0	100.0	100.0	100.0

[1] Standard Metropolitan Statistical Areas.

Source: *Outdoor recreation: a legacy for America—Appendix "A": an economic analysis*, op. cit.

tion occurred on weekends on National Forests and 40 percent for National Parks and Monuments. Still, this peaking of use on weekends and holidays is an important factor in managing and supplying outdoor recreation opportunities.

The 1972 Bureau of Outdoor Recreation survey also included data on the characteristics of outdoor recreation participants (table 14). Participants were predominately from metropolitan areas. Also people in the middle and upper income groups participated more than those in the lower categories. In comparison to the age distribution of the population, a disproportionately higher share of the participants were in the 18–24 and 25–44 age groups.

The 1972 survey showed that participation in outdoor recreation had risen substantially since the preceding survey in 1965. The increase was most noticeable for camping in remote or wilderness areas. Other activities for which participation more than doubled were camping in developed campgrounds, picnicking, canoeing, nature walks, swimming, and fishing. In addition, substantial increases were reported for sightseeing and hiking.

The yearly use reports by the National Forest Service and National Park Service also show large increases in the number of visitors. National Park System visits increased from 33 million in 1950 to 217 million in 1974. Similar increases were recorded on the National Forests. However, the type of recreation use reported differed markedly on National Forest and National Park lands. Most recreation visits to the National Parks occurred in areas that are well developed, such as campgrounds and visitor centers. In the National Forests, about 60 percent of the use occurred in dispersed areas where the most popular activities are camping, recreation travel, hunting, and fishing (table 15).

Over the 1968–1974 period in which the Forest Service has been keeping detailed records, not all activities have grown at the same rate. Some, such as picnicking, show only a slight increase, while organizational camping and recreation residence use has decreased. The declines have been caused in part by management practices, such as closing sites, which has the effect of reducing available opportunities. Major increases have often been stimulated by technological advances. Snowmobiling, motorcycling, all-terrain vehicle travel, backpacking, and rafting are examples of activities which have caused major management problems because of the sudden change and relatively large land areas they require.

Determinants of Demand for Outdoor Recreation

Growth in population of the magnitudes assumed in this study (an increase of 83 million people by

Table 15. *Estimated outdoor recreation use on National Forest System land in the United States, by type of activity, 1968 and 1974*

(*Thousand recreation visitor days*[1])

Activity	Total		Developed sites		Dispersed sites	
	1968	1974	1968	1974	1968	1974
Camping	39,214	51,544	29,074	34,484	10,140	17,060
Picnicking	6,687	6,933	4,995	4,598	1,692	2,335
Recreation travel (mechanized)	36,520	44,333	110	133	36,410	44,200
Boating	3,837	5,790	931	1,429	2,906	4,361
Water skiing and other water sports	605	1,154	62	39	543	1,115
Swimming and skuba diving	2,855	3,929	1,429	1,542	1,426	2,387
Fishing	14,523	16,403	201	264	14,322	16,139
Winter sports	5,676	8,377	4,940	7,094	736	1,283
Games and team sports	540	748	508	714	32	34
Resort and commercial public service	3,967	3,934	3,967	3,934	.....	.....
Organization camp use	4,498	4,233	4,494	4,225	4	8
Recreation residence use	8,151	6,980	8,097	6,977	54	3
Hunting	14,049	14,423	28	4	14,021	14,419
Hiking and mountain climbing	4,546	8,515	57	132	4,489	8,383
Horseback riding	2,057	2,815	20	19	2,037	2,796
Gathering forest products	1,283	2,188	14	10	1,269	2,178
Nature studying	850	1,012	131	75	719	937
Viewing scenery, sports, environment	5,078	6,185	2,115	2,122	2,963	4,063
Visitor information	1,780	3,420	1,204	2,163	576	1,257
Total	156,716	192,916	62,377	69,958	94,339	122,958

[1] Recreation use which aggregates 12 person hours. May entail 1 person for 12 hours, 12 persons for only 1 hour, or any equivalent combination of individual or group use.

2020 under the medium projection) will obviously have a major impact on the demand for outdoor recreation. Changes in the age distribution of the population, and especially the projected decline in the number of people in the 10–24 age class and the increase in the 25–44 and 45–64 classes, will strongly influence demands for certain kinds of activities [2] (table 16, fig 14).

In general, young people have a disproportionately higher rate of participation in outdoor recreation activities. The 1972 Bureau of Outdoor Recreation survey showed that the more strenuous activities are especially youth-oriented—water skiing, snow skiing, backpacking, motorcycle riding, and mountain climbing (table 16). As people age, they become more selective in their preferred activities, and the percentage of people who participate declines. Only seven of the 30 activities identified in table 16 were evenly distributed across age classes; even for these, participation dropped markedly for the over-65 age group.

Income also plays an important role in determining participation in outdoor recreation. People in the middle and upper income groups participate more than those in the lowest category (table 13). However, analysis of the data from the 1972 Bureau of Outdoor Recreation Survey[3] indicated that participation in most activities was not very sensitive to moderate changes in income. In the cases where income was significant, only a 0.09 to 0.35 percent increase in use occurred when incomes were raised 1 percent. Activities that appear to be most affected

[2] Marcin, Thomas C., and David W. Lime. Our changing population structure; what will it mean for the future outdoor recreation use? National Symposium on Economics of Outdoor Recreation, New Orleans, La. Nov., 12, 1974. (In process.)

[3] *Outdoor recreation: a legacy for America—Appendix "A": an economic analysis*, op. cit.

Table 16. *Percentage distribution of participation in selected outdoor recreation activities in the contiguous States, by age class, summer 1972 and fall and winter 1965*

Activity	Age class				
	12–17	18–24	25–44	45–64	65 and over
Attending outdoor concerts, dramas, etc.	7.6	12.9	4.7	6.0	2.5
Attending outdoor sports events	18.1	15.1	12.3	8.6	5.3
Bicycling	31.9	12.6	7.8	3.9	1.6
Birdwatching	3.7	2.8	4.7	4.6	2.1
Boating (other than sailing and canoeing)	19.6	16.7	17.7	11.5	3.6
Camping in developed campground	19.2	12.9	13.2	7.1	2.4
Camping in remote or wilderness area	8.2	6.9	6.3	2.4	0.3
Canoeing	4.4	4.9	3.5	1.2	.6
Driving for pleasure	30.0	44.4	36.1	32.2	26.0
Driving 4-wheel vehicle off road	3.4	2.3	2.3	.6	.2
Fishing	31.3	26.7	28.9	18.3	10.5
Golf	4.3	5.8	4.8	6.2	1.2
Hiking with pack/mountain and rock climbing	12.7	8.4	5.2	2.1	.3
Horseback riding	15.4	9.8	3.8	1.4	.2
Hunting[1]	15.0	18.0	14.0	9.0	4.0
Nature walks to observe birds, plants, etc.	23.7	22.5	18.9	12.5	5.0
Picnicking	49.3	53.5	55.1	41.2	24.8
Playing other outdoor sports (not golf and tennis)	47.4	30.2	24.9	8.6	2.6
Riding motorcycles off the road	10.4	8.9	4.5	1.0	.3
Sailing	4.2	3.9	2.2	2.0	.7
Sightseeing	38.9	38.3	40.2	38.5	25.6
Swimming—outdoor pool	38.6	23.1	18.2	9.7	2.6
Swimming—other outdoor	56.7	47.0	41.8	17.5	4.4
Tennis	11.7	10.6	4.5	1.6	.5
Visiting zoos, fairs, amusement parks	33.2	29.0	29.4	17.0	8.2
Walking for pleasure	49.5	41.7	34.1	27.8	19.0
Water skiing	8.1	10.8	6.8	1.0	0.0
Wildlife and bird photography	2.5	2.7	2.3	1.6	.6
Ice skating[1]	29.0	18.0	7.0	2.0	.....
Snow skiing[1]	10.0	8.0	3.0	1.0	.....
Sledding[1]	40.0	20.0	13.0	2.0	.....
Other activities	30.1	29.2	24.1	21.3	17.4

[1] 1965 data.

Sources: U.S. Department of the Interior, Bureau of Outdoor Recreation. *The 1965 survey of outdoor recreation activities.* Government Printing Office, Washington, D.C. 101 p. 1967, and *Outdoor recreation: a legacy for America—Appendix "A": an economic analysis*, op. cit.

Projections of total U.S. population, by age class

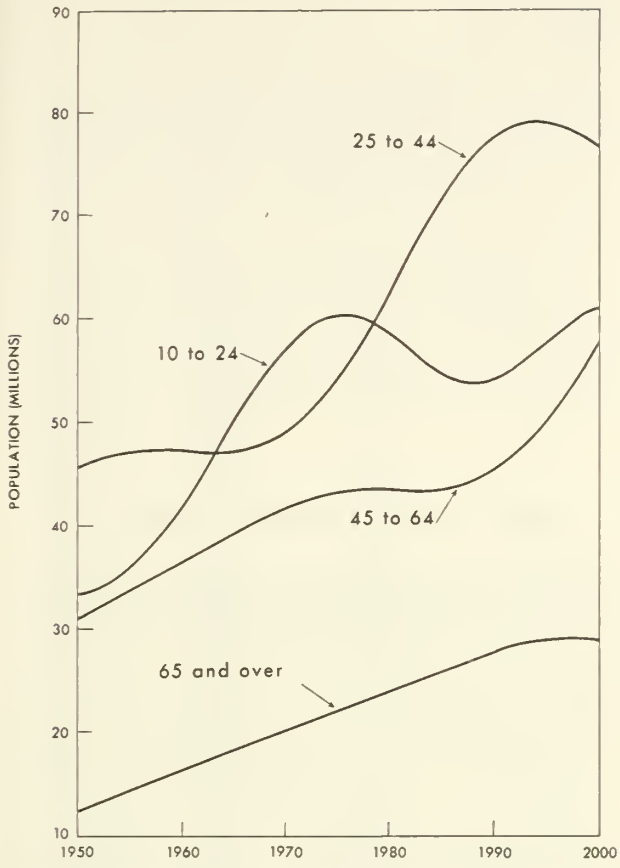

Figure 14

The 1972 Bureau of Outdoor Recreation survey showed that the more strenuous activities are especially youth-oriented.

by income include camping, driving off-road recreation vehicles, and boating.

The cost of travel is another important influence on demand. The mobility provided by automobiles has been a key factor in providing access to forest and range lands. In effect the automobile has enabled Americans to enjoy a broad range of recreation opportunities.

The 1972 Bureau of Outdoor Recreation Survey provided an insight into the effect that travel distances have on outdoor recreation. It was found that 97 percent of the vacations and 83 percent of the overnight trips involved roundtrip distances of more than 200 miles. The "get away from it all" phenomenon was also reflected in the statistics for day outings (no overnight stay) and short outings (less than 4 hours). Fifty-five percent of the day outings involved roundtrip distances of over 110 miles and 45 percent of the short outings involved distances of over 40 miles.

Analysis of the travel data in the 1972 Bureau of Outdoor Recreation Survey also indicated that participation in the various activities is not very sensitive to moderate changes in transportation costs—0.06 to 0.35 percent reduction in use occurred when costs were raised. In 1974, participation figures from National Forests supported these findings. The rate of increase in recreation was not significantly affected by the increase in fuel costs that occurred during 1974.

Demand Projections

The above variables were used in conjunction with the participation functions developed from the 1972 Bureau of Outdoor Recreation Survey.[5] Since the participation functions were only for summer activities, projections were not made for those activities that take place mainly in the other seasons. However, prospective increases in demand for activities such as skiing are discussed later. In order to get the data on a common statistical basis and facilitate comparisions of projected changes in activities, the projected participation has been converted to an index basis, with 1975 as the base year. For the analysis, it was assumed that travel costs would double by 1980 and then would increase 10 percent per decade.

The projections indicate substantial growth in demand for the major types of summer outdoor recreation (table 17). There are, however, large differences in the size of the projected increases. Sailing

[5] For details on the procedures used see:

Outdoor recreation: a legacy for America—Appendix "A", an economic analysis, op. cit., and

David B. McKeever. Long-term projections of demand for forest related outdoor recreation in the United States. Penn State Univ., Master's Thesis. 1975. (Unpublished.)

Table 17. *Projected indexes of demand for outdoor recreation in the contiguous States, by major activity, 1975–2020*

(1975=100)

Activity		Year					
		1975	1980	1990	2000	2010	2020
Remote camping	High	100	106	117	143	177	217
	Medium	100	106	116	133	156	180
	Low	100	106	114	126	141	156
Developed camping	High	100	106	116	138	162	199
	Medium	100	106	114	129	143	165
	Low	100	106	113	122	130	143
Motorcycling	High	100	106	115	137	161	189
	Medium	100	106	113	126	140	154
	Low	100	106	111	118	126	132
Off-road driving	High	100	107	118	145	175	209
	Medium	100	107	116	133	153	172
	Low	100	107	114	124	137	148
Photography	High	100	109	128	162	204	253
	Medium	100	109	126	153	183	212
	Low	100	109	125	146	168	186
Birdwatching	High	100	107	122	143	168	197
	Medium	100	107	121	138	153	168
	Low	100	107	120	134	143	149
Hiking	High	100	106	116	138	163	192
	Medium	100	106	114	128	143	158
	Low	100	106	112	120	129	136
Nature walks	High	100	106	118	144	174	213
	Medium	100	106	117	135	155	178
	Low	100	106	115	128	141	155
Pleasure walks	High	100	107	117	139	161	188
	Medium	100	107	116	130	144	157
	Low	100	107	114	124	131	137
Bicycling	High	100	107	117	156	212	283
	Medium	100	107	114	139	179	226
	Low	100	107	111	126	157	189
Horseback riding	High	100	106	115	138	164	194
	Medium	100	106	113	127	142	158
	Low	100	106	111	118	128	136
Water skiing	High	100	110	128	167	215	270
	Medium	100	110	126	155	190	224
	Low	100	110	124	146	172	195
Canoeing	High	100	106	117	143	178	220
	Medium	100	106	115	132	156	181
	Low	100	106	113	124	141	157
Sailing	High	100	114	144	205	324	485
	Medium	100	114	143	195	292	410
	Low	100	114	142	188	270	362
Other boating	High	100	107	122	154	198	251
	Medium	100	107	120	145	176	210
	Low	100	107	119	138	162	183
Swimming	High	100	107	117	140	165	198
	Medium	100	107	115	130	145	163
	Low	100	107	114	123	132	142
Sightseeing	High	100	107	119	140	164	191
	Medium	100	107	118	133	147	161
	Low	100	107	117	127	136	142
Picnicking	High	100	106	115	134	156	186
	Medium	100	106	114	126	139	155
	Low	100	106	113	120	127	135

more than quadruples by 2020, under the medium level assumptions on population and economic growth, while activities such as photography, bicycling, and water skiing more than double. Generally, activities that directly relate to water all show significant increases. The smallest increases were for activities such as motorcycling, hiking, picnicking, and horseback riding. Part of the difference in the projected rate of growth is due to those assumptions about the changing age structure of the population.

The alternative assumptions on population, economic growth, and income have substantial impacts on projected demands particularly in the decades after 1990. The high projection of demand for bicycling in 2020, for example, is some 50 percent above the low projection.

Developed Recreation Activities

Developed, or concentrated, recreation is defined as outdoor recreation requiring significant capital investment in facilities to enable the concentration of visitors on a relatively small area. Sites may be developed because of their specific capabilities such as downhill skiing or to permit use which might otherwise be nonavailable because of fire hazards or fragile environments. Sites may also be developed in order to inform and educate people at a central location such as a visitor center at the entrance of a backpacking area or to make it economically feasible to provide services such as drinking water, sanitation, and other conveniences which enhance the recreation experience. The nature of developed outdoor recreation is such that a number of opportunities may attract entrepreneurs to provide services on either private or public lands.

Although a distinction is made in this study, developed and dispersed recreation activities are often complementary. As an example, a developed campsite can serve as a base for hunting or fishing trips. Likewise, a ski lodge can serve as an embarking point for cross-country as well as downhill skiing.

The Demand and Supply Situation for Developed Camping

The Bureau of Outdoor Recreation reports that about two-thirds of the camping activity in the summer of 1972 occurred in developed campgrounds (table 13), a percentage that has remained relatively constant since the first national survey in 1960.[6] On National Forest land, about two-thirds of all camping occurs at developed sites (table 15). For the most part, this is a family activity.[7] Studies of campers in the Northeast indicate that more than 90 percent of the camping parties were families or families camping with friends.[8]

The biggest investment made by most campers is for the shelter which they take with them on a camping trip. The tent has been the traditional shelter for many years and continues to be popular. However, an expanding recreation vehicle industry has provided more and more campers with sophisticated, convenient shelters (table 18). Overall, there were about 5.0 million of these in use in 1975, including approximately 2 million travel trailers, 0.8 million truck campers, 1 million camping trailers, 0.3 million motor homes, and 1 million pickup covers.

Projected demand for developed camping.—Few outdoor recreation activities have surpassed camping in sustained growth. It was estimated that 4.3 million households camped in 1960.[9] By 1965, the number had grown to 6.0 million. In 1973, a study sponsored jointly by selected camping industries and the Forest Service in cooperation with Opinion Re-

[6] Outdoor Recreation Resources Review Commission. Outdoor recreation for America. Report to the President and Congress, Study Rpt. 19, 394 p. 1962.

[7] LaPage, Wilbur F. Growth potential of the family camping market. U.S. Department of Agriculture Forest Service, Northeastern For. Exp. Sta., Upper Darby, Pa. Res. Pap. NE-252. 1973.

[8] Buxton, Stanley F., and Johannes Delphendahl. Campers at Lily Bay State Park—socio-economic characteristics and economic impact. Maine Agr. Exp. Sta. Bull. 687, 28 p. 1970, and Roenigk, William P., and Gerald L. Cole. A profile of Delaware campers. Delaware Agr. Exp. Sta. Bull. 370, 14 p. 1968.

[9] Outdoor recreation for America. Report to the President and Congress. op. cit.

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Camping has been one of the fastest growing outdoor recreation activities. Further growth is expected.

Table 18. *Recreation vehicle production in the United States, 1961–74*

(*Thousands*)

Year	Total shipment	Travel trailers	Truck campers	Camping trailers	Motor homes	Pickup covers	Percent increases all types
1961	63	29	16	18	.....	.....	
1962	80	41	17	23	.....	.....	+28.3
1963	119	52	27	40	.....	.....	+47.7
1964	151	64	35	52	.....	.....	+27.3
1965	193	77	44	67	5	.....	[1]+24.6
1966	220	87	55	72	6	.....	+14.0
1967	244	95	62	79	9	.....	+11.2
1968	483	115	80	125	13	150	[2]+36.3
1969	514	144	93	141	23	114	+6.4
1970	472	138	96	116	30	92	−8.2
1971	549	191	107	96	57	98	+16.4
1972	748	251	105	110	117	165	+36.2
1973	753	212	90	98	129	224	+0.7
1974	549	134	48	58	70	241	−27.0

[1] Motor homes not included.

[2] Pickup covers not included.

Note: Recreation Vehicle Institute surveys began in January 1968. Production information prior to that date was obtained from best sources available and was revised to reflect Recreation Vehicle Institute survey methods and information.

Sources: Recreation Vehicle Institute. *Recreation vehicle industry facts and trends.* (16 p.), and *Recreation vehicle shipment forecast 1975.* (6 p.) Des Plains, Ill. 1974.

search Corporation reported that 14.3 million households camped.[10]

Even so, there are some indications that demand for developed camping might be approaching a temporary saturation point. For instance, an investment banker described the campground industry as approaching a level of development where "the period of rapid growth is over, and an individual company's growth must be achieved largely through gains in market share."[11] In a study of trends in family camping participation, 1964–68, each camping family that increased its volume of camping was offset by two other families who camped less each year.[12] Recent findings from a follow-up to that survey indicate that 20 percent of the panel members were no longer active campers, another 33 percent had decreasing camping participation trends from 1968–71, and the 20 percent with increasing trends quite frequently reported that they were enjoying it less.[13] An impressive proportion (35 percent) of all panel members said that campground conditions were deteriorating and that a new breed of inconsiderate campers was taking over.

Further insight into the current dynamics of the camping market was provided by two national participation studies conducted in 1971 and 1973.[14] It was found that active campers as a group comprise about 21 percent of the households in the United States (table 19). Among these campers, average participation was either decreasing or remaining relatively constant. In both the 1971 and 1973 national surveys, the lower income groups were the ones most likely to show an interest in camping.

While the numbers of campers has been increasing, the number of potential campers has been declining. In 1960, it was estimated that 9 million households would like to try camping in the future. In 1973, only 6 million households were interested.

Nonetheless, the demand for developed camping (medium level) is projected to increase 65 percent by 2020—a reflection of the rather large assumed increases in population, income, leisure time, and other related determinants (table 17). Under the alternative assumptions on growth in population, economic activity, and income, projected demand for developed camping in 2020 ranges from an increase of 43 percent to 99 percent.

Supply of developed camping.—Camper requirements vary with the equipment used. The motor

[10] Kottke, Marvin W., and Malcolm I. Bevins, Gerald L. Cole, Kenneth J. Hock, and Wilbur F. LaPage. Analysis of the campground market in the northeast—Report III: a perspective on the camping-involvement cycle. U.S. Department of Agriculture Forest Service, Northeastern For. Exp. Sta., Upper Darby, Pa., Res. Pap. NE–322. 1975.

[11] Peterson, James. The camping industry as an investment. Proceedings, First Annual Family Camping Federation American Camping Congress, p. 146–157. 1971.

[12] LaPage, Wilbur F., and D. P. Ragain. Family camping trends—an eight year panel study. J. Leisure Res. 6(2):101–112. 1974.

[13] Ibid.

[14] LaPage, growth potential of the family camping market, op. cit., and Kottke, et. al., op. cit.

Table 19. *Camping interest in the contiguous United States, in 1960, 1971, and 1973*

(*Percent*)

Adult respondent	Year		
	1960	1971	1973
1. Has camped in the past year with family or friends	15	19	21
2. Has camped, but not in past year	[1]	14	20
3. Never camped but may try camping in future	9	15	9
4. Never camped and not interested; no answer	76	52	50
Total	100	100	100

[1] Not asked.

Sources: 1960—Outdoor Recreation Resources Review Commission. *Participation in outdoor recreation—factors affecting demand among American adults.* Study Report No. 20. 1962; 1971—LaPage, Wilbur F. *Growth potential of the family camping market*—U.S. Department of Agriculture Forest Service, Northeastern For. Exp. Sta., Upper Darby, Pa. Res. Pap. NE-252. 1973; and 1973—Kottke, Marvin W., and Malcolm I. Bevins, Gerald L. Cole, Kenneth J. Hock, and Wilbur F. LaPage. *Analysis of the campground market in the Northeast—report III: a perspective of the camping-involvement cycle.* U.S. Department of Agriculture, Forest Service, Northeastern For. Exp. Sta., Upper Darby, Pa. Res. Pap. NE-322. 1975.

home needs only a place to park, to deposit wastes, refill with fuel and water, and usually an electric hookup. The tent camper generally is attracted to developed campgrounds where water, sanitary facilities, tables, and fireplaces are provided.

Also camper requirements vary because some campgrounds, especially those in and near national and State parks and forests, serve primarily as destination camps, where people stay for a period of time to enjoy camping and the recreation activities available in the surrounding environment. Other campgrounds serve primarily as overnight stopovers for campers enroute to other destinations. Of course, many campgrounds serve both purposes and the classification is just a matter of location and emphasis.

In 1960, according to the Outdoor Recreation Resources Review Commission, public campgrounds and trailer camps had a capacity of about 829,000 persons. By 1965, the Bureau of Outdoor Recreation reported public campgrounds and trailer camps had a total capacity of 1,347,770. And in 1972, the Bureau of Outdoor Recreation estimated that public capacity had reached 1,745,595.[15]

[15] *Outdoor recreation: a legacy for America—Appendix "A": an economic analysis*, op. cit.

The 1965 survey by the Bureau of Outdoor Recreation provided a break-down in capacity between public and private sectors as follows:

Ownership	*Capacity (number of persons)*		
	Total	*Tent camps*	*Trailer camps*
Public	1,347,770	238,575	1,109,195
Private	2,941,710	1,480,080	1,461,630
Total	4,289,480	1,718,655	2,570,825

Another indicator of campsite growth is provided by figures from private directories. For instance, Woodall's Camping Directory[16] shows campground listings growing from 444,000 in 1967 to 965,000 in 1974. Of the 1974 total, 8.2 percent were managed by the U.S. Forest Service, 2.8 percent National Park Service, 22 percent other public agencies, and 7.5 by a single private campground franchiser. During this time period, the private sector increasingly accounted for a larger share of the developed campsite market (table 20). Based on Woodall's statistics, the number of private campsites increased 140 percent from 267,000 in 1967 to 644,000 in 1974, while public campsites increased 81 percent from 177,000 to 321,000.

Table 20. *Developed campsites in the United States, 1967–75*

(*Thousands*)

Year	Public campsites	Private campsites	Total campsites
1967	177	267	444
1968	205	373	578
1969	230	426	656
1970	248	462	710
1971	286	534	820
1972	306	562	868
1973	306	584	890
1974	321	644	965
1975	322	643	965

Source: Woodall's Publishing Company. *Woodall's traveling parks and campgrounds directory.* Highland Park, Ill. Annual.

There are a number of possible reasons for the growth in facilities provided by the private sector:

—The demand for developed campgrounds increased tremendously both in terms of volume and in terms of willingness to pay for "full-service" convenience-oriented camping.

—The number of public campgrounds has not grown fast enough to meet the demand. Federal recreation budgets have been especially low the past few years.

[16] Woodall's Publishing Company. Woodall's traveling parks and campgrounds directory. Highland Park, Ill. Annual.

—The initiation of fees for public campgrounds improved the competitive position of private campgrounds.

There are signs, however, that supply may be reaching a saturation point for the current market. For instance, a 1974 study of campgrounds in New York found an average summer occupancy of about 40 percent. The estimated long-term break-even point is approximately 65 percent. In that State, some 80 campgrounds have gone out of business since 1971. Similarly, Forest Service study of New Hampshire campgrounds has found that one in five campgrounds is for sale or was sold in the past year. Also, another one in five campground owners would sell if they thought they could get their money back. Thus, many private campground owners are finding it difficult to stay in operation under the present circumstances.

The projected growth in demand indicates that the present difficulties are likely to be temporary. In a relatively short period of time, demand will exceed the capacity of existing facilities.

Opportunities for developing more campsites.—Although campsites close to lakes and streams are usually the most desired, forest and range lands have the physical capacity to support the development of almost any required number of campsites. Thus, projected demands can be met if the necessary investments are made in facilities.

At this time, opportunities to increase camping facilities are most promising in the Northeast and South.[17] Together, these regions account for 70 percent of the potential campers (table 21). This concentration of potential campers may be due in part to the historical development of fewer public campsites per capita in these regions than in the North Central or Western regions.[18] A larger proportion of

[17] Kottke et. al., op. cit.

[18] Outdoor recreation for America. Report to the President and Congress, op. cit.

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The forest and range lands and associated inland waters have the physical capacity to meet demands for camping and most other kinds of outdoor recreation.

Table 21. *Distribution of residence of all households and campers in the contiguous States, by region, 1973*

Region of residence	All households		Active campers		Potential campers		Nonmarket households	
	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent
Northeast	16,320	24	2,002	14	2,074	34	9,860	29
North Central	19,040	28	3,289	23	1,098	18	10,880	32
South	21,760	33	4,433	31	2,196	36	10,540	31
West	10,200	15	4,576	32	732	12	2,720	8
Total	67,320	100	14,300	100	6,100	100	34,000	100

Source: Kottke, et al., op. cit.

Table 22. *Public and private developed campsites in the contiguous States, by region, 1974*

Region	Total		Private		Public	
	Thousands of sites	Percent	Thousands of sites	Percent	Thousands of sites	Percent
Northeast	166	17	132	21	34	10
North Central	295	31	182	28	113	36
South	261	27	195	30	66	21
West	239	25	133	21	106	33
Total	961	100	642	100	319	100

Source: *Woodall's traveling parks and campgrounds directory*, op. cit.

the North Central and Western populations have already tried camping. Over half of all developed campsites are in these two regions (table 22).

Opportunities also exist for development of campgrounds catering to the needs of special groups. For example, campsites with showers could be built to serve as base camps for backpackers or mountain climbers. Special information about these activities could be provided to visitors at these sites and the whole area developed around their needs.

The Demand and Supply Situation for Skiing

Snow skiing has become an increasingly popular form of outdoor recreation. In 1972, the Bureau of Outdoor Recreation reported that 7.2 million people (5 percent of the population 12 years and older) skied. This compares with the 2.6 million persons or 2 percent of the population reported as skiing in 1960. About 40 percent of the skiers lived in the Eastern United States, 30 percent in the West, 25 percent in the Midwest, and 5 percent in the South.

Industry figures support the increasing popularity of skiing. For instance, a 1972–73 survey of members of the Professional Ski Instructors revealed that they gave 30 million hours of ski instruction. Ski

Snow skiing has become increasingly popular. More than 5 percent of the population 12 years and older participates.

Area Management magazine reported that a total of 76 new lifts were installed in 1974. A total of 2,333 cable lifts are available to serve the public.[19] In addition, R. A. Des Rockes of Ski Industries of America estimates that retail sales of ski clothing, equipment, footwear, and accessories has grown from $58 million in 1960 to $445 million in 1974.

[19] Ericksen, Niles. Lifts 1974. Ski area management. 14(1):35–38. 1975.

Table 23. *Characteristics of skiers in the United States, by region, 1969*

(Percent)

Characteristics	Region			
	National	East	West	Midwest
Age:				
Under 18	18	16	26	16
18–24	27	24	32	28
25–34	28	30	22	31
35–44	18	19	14	18
45–54	7	8	5	6
55+	1	2	1	1
No answer	1	1	.....	.....
Total	100	100	100	100
Marital status:				
Single	57	52	55	68
Married	41	46	42	31
Other	2	2	3	1
Total	100	100	100	100
Sex:				
Male	57	58	57	54
Female	43	42	43	46
Total	100	100	100	100
Occupation				
Student	33	27	32	43
Professional	22	22	22	22
Housewife	13	13	15	8
White collar	18	22	16	17
Other	14	16	15	10
Total	100	100	100	100
Annual household income:				
$0–$9,999	28	26	31	22
$10,000–$19,999	36	36	33	39
Over $20,000	22	24	22	22
No answer	14	14	14	17
Total	100	100	100	100

Source: United States Ski Association. *The United States Ski Association and the modern American skier.* Info. Bull., Denver, Colo. 1973.

Characteristics of skiers.—There are not very many studies containing original data on skiers.[20] Part of the reason is that skiers are a small part of the total population and it has been difficult to get a sample that is statistically valid. Regional studies do exist for the Northeastern States,[21] the Western States,[22] and the Midwestern States,[23] and a national study was done in 1973 by the United States Ski Assocation.[24]

These studies all indicate that skiers are young; about two-thirds were under 30 years of age (table 23). The tendency of the sport to attract younger

[20] Goeldner, Charles F., Karen P. Dicke, and Gerald L. Allen. Colorado ski and winter recreation statistics. Bus. Res. Div., Grad. School of Bus. Admin., Univ. of Colo., Boulder, Colo. 1972.

[21] Sno-Engineering, Inc. The skier market in Northeast North America. U.S. Department of Commerce, Area Redevelop. Admin., 181 p. 1965.

[22] Herrington, Roscoe B. Skiing trends and opportunities in the Western States. U.S. Department of Agriculture Forest Service, Intermountain For. Exp. Sta., Ogden, Utah. Res. Pap. INT–34, 90 p. 1967.

[23] Leuschner, William A. Skiing in the Great Lakes States: the industry and the skier. U.S. Department of Agriculture, Forest Service, North Central For. Exp. Sta., St. Paul, Minn., Res. Pap. NC–46, 42 p., illus. 1970.

[24] United States Ski Assocation. The United States Ski Assocation and the modern American skier. Info. Bull. Denver, Colo., 1973.

people reflects the fact that skiing is an active sport requiring greater stamina and endurance than most other forms of outdoor recreation. The heavy proportion of young people within the skier population has strong implications for the future growth of skiing as a recreation activity.

Skiers were also found to be more affluent than the average citizen; in most cases their income was 25 to 30 percent higher. This was especially true of nonresident skiers. These findings were supported in a 1974 study of nonresident skiers arriving by airlines in Colorado.[25] Twenty percent of these skiers reported annual incomes in excess of $50,000. It was also reported that the average skier who used commercial airlines to reach Colorado ski areas spent $1,274 per trip.

In both the Western and Midwestern regional studies, local residents accounted for about 85 percent of the days skied (table 24). In addition, most skiers (between 80 and 90 percent) took only single-day trips, weekend trips, or a combination of the two.

Projected demand for skiing.—On the basis of the assumptions about population and income growth and skier characteristics, the demand for skiing (medium level) is projected to rise by 92 percent by 2000 and more than double by 2020. Although these are large increases, the growth rate is slower than it was during the mid-1960's and early 1970's. The aging of the population and the reduction in the number of people in the 14–24 age group is an important cause of the lower rate. Also, a limited number of individuals will have the high incomes needed for ski vacations.

[25] Goeldner, Charles R., and David Maltais. The airline skier. Bus. Res. Div., Grad. School of Bus. Admin., Univ. of Colo., Boulder, Colo. 1974.

Table 24. *Percentage of skiers taking various combinations of trips in the Midwest and West, 1964–65 and 1968–69*

Year (region)	Day only	Weekend only	Day and weekend	Other	No response
1964–65 (West)	46	13	23	18	0
1968–69 (Midwest)	58	15	17	7	3

Sources: Leuschner, William A. *Skiing in the Great Lakes: the industry and the skier.* U.S. Department of Agriculture, Forest Service, North Central For. Exp. Sta., St. Paul, Minn., Res. Pap. NC–46, 42 p., illus. 1970; and Herrington, Roscoe B. *Skiing trends and opportunities in the western States.* U.S. Department of Agriculture Forest Service, Intermountain For. Exp. Sta., Ogden, Utah, Res. Pap. INT–34, 90 p. 1967.

The demand for skiing in the West will be dependent on a continuation of the past trends of skiers to take ski vacations. This will be influenced by increasing costs of travel resulting from the recent energy crisis. Increased costs of traveling in Europe have already caused many people to give up European ski vacations.

In the future, as indicated in the tabulation below, the alternative assumptions about population and income growth have substantial impacts on projected demands for skiing in the decades after 1990 but substantial growth is still anticipated under all assumptions.

	Projected demand for skiing (Index: 1975=100)					
Level of demand	*1975*	*1980*	*1990*	*2000*	*2010*	*2020*
High	100	120	158	214	270	333
Medium	100	120	154	192	230	266
Low	100	120	150	176	202	223

Supply of ski facilities.—The development of facilities oriented around downhill skiing depends on suitable terrain and weather conditions that will give adequate snowfall. In some cases, snow making machines can be used to extend the season or range.

There are presently 2,333 cable ski lifts in the United States. Forty-three percent are located in the East, 40 percent in the West, and 17 percent in the Midwest. This roughly approximates the percentage of skiers located in each region. However, the number of lifts is not an accurate measure of the skiing opportunity or the capacity of a region to supply uphill transportation to skiers. A long lift going to the top of a long steep hill provides a longer ride and a more challenging skiing experience than does a short lift to the top of a gentle hill. The concept of "vertical transport feet" (VTF) has been developed to provide a more meaningful interpretation of capacity. One vertical transport foot is the capacity to raise one skier one foot vertically per hour.[26]

Using the VTF measure of lift capacity, a different pattern of relative skiing opportunity within the three regions is apparent (table 25). For instance, while the Midwest had 9 percent of the total number of new lifts installed in the nation during 1974, this represented only 4 percent of the capacity in VTF. Because longer lifts and steeper mountains are common to the West, this region generally produces more capacity per lift than does either the East or the Midwest regions.

The availability of ski facilities can also be viewed in terms of ski areas. In 1974, the University of Colorado conducted a national survey of all ski areas in

[26] Sno-Engineering, Inc., op. cit.

Table 25. *New lift construction and capacity in the United States, by region, 1974*

Regions	New lifts 1974		Capacity	
	Number	Percent	Millions of vertical transport feet	Percent
East	21	28	13.4	23
Midwest	7	9	2.4	4
West	48	63	41.3	73
Total	76	100	57.1	100

Source: Ericksen, Niles. *Lifts 1974*. Ski area management, New York, N.Y. 14(1):36–38. 1975.

the National Ski Areas Association.[27] Athough the Association membership undoubtedly represents the larger and better known areas in the Nation and, for that reason, is a biased sample, this survey is the most up-to-date summary available. The report estimates that the survey included about 50 percent of the total capacity (measured in VTF's) in the Nation.

Three categories of ski area were recognized: day areas, weekend areas, and vacation areas, each with its own unique characteristics. Most of the larger vacation-type ski areas were located in the West, particularly in the Rocky Mountains. In general, the larger vacation ski areas and weekend sites provide increased lift capacity and more varied recreation activities in addition to skiing. Nearly 50 percent of the ski areas in the study operate at least partially on National Forest land. Real estate development activities, such as vacation homes and condominiums, and revenue from lift ticket sales, accounted for 54 percent of the revenue at the average ski area.

Opportunities for developing new ski areas.—New ski areas will be required over the years to meet the growing demands. Opportunities exist for developing new ski facilities in all of the regions where skiing is now an established winter activity. Also, in the future, many ski area operators will need to upgrade or modernize existing facilities.

Development in the West will depend largely on Forest Service and local government. The western National Forests generally are located in prime skiing terrain. However, there is a significant acreage of privately owned land with the physical attributes required for ski area development. Most Western ski resorts involve the development of both public and private lands. The extent to which the National Forests are used for skiing will depend not only on the public demand for skiing opportunities but also on the land made available for this use in relation to other competing uses, and the availability of private investment capital.

In the past, much attention has been given to the high income vacation skiers. These skiers contribute significantly to the economies of the States they visit such as Colorado, Utah, Vermont, Montana, Wyoming, and New Hampshire. In the New England States, Colorado, and Utah, for example, nonresident skiers far outnumber residents. On the other hand, California, Oregon, and Washington areas serve mostly the resident populations. As can be expected, these resort oriented States have enjoyed a far greater growth in the past, and can expect greater pressures for growth in the future. But, as pointed out earlier, only 10–20 percent of the skier population take ski vacations in any given year. Many skiers may take only a few vacations during a lifetime; other may regularly enjoy a winter ski vacation.

Therefore, the potential future rate of growth in demand for the western skiing will be dependent on trends in skiing vacations. These trends will be influenced by increasing costs of travel resulting from the recent energy crisis. Increased costs of travelling in Europe have already influenced many skiers to abandon their past habits of European ski vacations. To date, attendance at ski areas in the United States has not been reduced by either the recession or higher costs for energy and travel, but has continued to increase. The rising costs of ski tickets, ski equipment, and transportation coupled with the anticipated reduction in the number of people in the younger age groups of the population all suggest a declining rate of growth in the future.

The Demand and Supply Situation for Other Developed Activities

Both camping and skiing require a substantial investment in equipment by users, but there are other activities that do not require much equipment. The most popular are picnicking and swimming.

[27] Goeldner, Charles R., and Karen P. Dicke. Economic analysis of North American ski areas. Bus. Res. Div., Grad. School of Bus. Admin., Univ. of Colo., Boulder, Colo. 123 p. 1974.

The Bureau of Outdoor Recreation[28] estimated that 47 percent of the population 12 years and older picnicked in the summer of 1972 while 18 percent swam in swimming pools and 34 percent swam in other areas (table 13). Results of the 1972 survey also showed that picnicking and swimming are popular irrespective of the region of the country, urban or rural residence, or race.[29] On the average, though, women tend to participate more than men, and individuals living in households with income under $3,000 participate less that those with higher incomes. For swimming, those under 45 tend to participate more, and individuals living in households with incomes under $3,000 participate less.

Activities such as picnicking and swimming are popular because they are simple, cost little, give people an opportunity for social contact and relaxation, and people of all ages can participate. Little cash outlay is required, although some people purchase ice chests and other equipment such as portable tables, chairs, and stoves. It is expected that the demand for picnicking and swimming will continue to grow fairly rapidly in the coming years (table 17).

Although picnicking and swimming can take place without developed facilities, Forest Service data show that developed locations are often preferred (table 15). In addition to rural settings, urban areas frequently have picnic grounds available at city parks or zoos and both public and private swimming pools and beaches. At this time, there is not a current listing of picnic or swimming sites, as the last complete inventory was conducted in 1965.[30]

There are many and varied opportunities to develop more facilities for picnicking and swimming on the Nation's forest and range lands and inland waters. Projected increases in demand can be met, but this would require substantial public and private investments in facilities, especially those designed to control pollution and protect the environment.

Visitors Centers and Interpretative Services

For many people, visitor centers with the associated interpretative services are an important part of the outdoor recreation experience. These facilities are often concentrated in areas of especially high use, and help orient visitors to recreation opportunities, interpret the natural and cultural history of the area, and develop an appreciation for the basic ecology, management, and use and protection of the Nation's forest and range lands and inland waters.

Interpretative services, available on many public forests and parks, develop an appreciation of the use and importance of the Nation's natural resources.

Projected demand for interpretive services.—The available data suggest that the use of visitor centers and interpretative services is increasing rapidly. The Nation's growing awareness of the importance of natural resources; interest in how they can be protected, managed, and used; along with the projected growth in other outdoor recreation activities suggests that demand is likely to continue to increase in the decades ahead.

Supply of facilities.—Interpretive services are available for part of the Nation's forest, range, and inland waters. On Federal lands, the National Park Service conducts the largest and the oldest program. This service began in Yosemite National Park in 1920;[31] today the National Park Service interprets human and natural history in some 300 areas. Other Federal agencies with interpretive programs include the Forest Service, Fish and Wildlife Service, Corps of Engineers, and the Bureau of Land Management. Currently, over 200 visitor centers are located on Federal lands. For each visitor center there are many natural trails, scenic overlooks, interpretive signs, amphitheaters, campfire circles, slide talks, brochures, and other interpretive aids.

A wide variety of interpretive programs are also available on non-Federal lands, and many of these deal in part with forest and range resources. Several States have very active interpretive programs in their State park systems and at roadside rest areas managed by State Highway Departments, and many counties, cities, and small communities have interpretive programs.

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[28] *Outdoor recreation: a legacy for America—Appendix "A": an economic analysis*, op. cit.

[29] Ibid.

[30] U.S. Senate Committee on Interior and Insular Affairs. The recreation imperative: a draft of the Nationwide outdoor recreation plan prepared by the Department of the Interior. 389 p. Sept. 1974.

[31] Weaver, Howard E. "Origins of natural history interpretation," in interpreting the environment. Accepted by John Wiley & Sons, N.Y., N.Y. (In press.)

Opportunities for further development of interpretive services.—While excellent interpretive programs have been developed over the years by various public and private organizations, the potential is still relatively undeveloped. There are many areas of great scenic and natural beauty, historic or prehistoric places, primitive areas, ecologically unique areas, parks, wildlife refuges, and National Forests that have little or no services of this kind. Opportunities exist through this method to help people develop outdoor habits that minimize human impacts on the land and to understand the land management philosophies and practices that go into management of our renewable natural resources.

Dispersed Recreation

Dispersed recreation is defined as outdoor recreation in which visitors are usually spread out over relatively large areas. This indicates dispersed camping, recreation travel of all kinds, and boating and canoeing. Where facilities or developments are provided for dispersed recreation, they are more for access and protection of the environment than for comfort or convenience.[32] For example, natural lakes and rivers provide an opportunity for swimming with no modification of the environment. In this case, swimming is a dispersed activity. With the improvement of a beach, construction of a bathhouse, parking lot, lifeguard station, and marker buoys, the activity becomes constrained to a definable area and is more properly defined as a developed site activity.

Forest and range land and inland waters provide an extensive base for dispersed recreation. These lands and waters offer a range of opportunities extending from wilderness to metropolitan environments. Each of these environments can offer a satisfying experience for the individual who seeks it out. Dispersed recreation is rarely an exclusive use. For example, it often exists compatibly with livestock grazing, wildlife production, timber harvest, or mineral extraction.

However, almost two-thirds of the country's forest and range lands is privately owned. Much of this land is close to urban centers where most potential recreation visitors reside. Much of this land is not available to the general public for recreation uses. The result is that the limited public lands and waters that are near large metropolitan areas are often heavily used for dispersed recreation. The advent of the off-road vehicle has greatly intensified the pres-

[32] Lloyd, R. Duane, and Verles L. Fischer. Dispersed versus concentrated recreation as forest policy. Proceedings of the Seventh World Forestry Congress. Buenos Aires, Argentina. 1972.

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The 48 million acres of inland waters offer almost endless opportunities for canoeing. Although most canoeing is spread over relatively large areas, some popular areas are becoming crowded and present difficult management problems.

sures and caused additional conflicts between user groups.

Over the past two decades, dispersed recreation uses on public lands have tended to concentrate in units of the National Wilderness System. This has probably been caused in part by the publicity associated with their establishment. Much of this use does not depend on a wilderness environment and the needs of users could be served as well on other forest and range land. "Back country" or "pioneer" areas currently being proposed could supply many of the demands for dispersed area recreation.

The Demand and Supply Situation for Dispersed Camping

People's preferences in outdoor recreation vary considerably according to their own personal tastes, skills, habits, and the time they have available. People intentionally seek out the sites that meet their own particular needs, whether it be a highly developed campground, a primitive campsite, or a transient camp in undeveloped country where facilities are very minimal or totally lacking.

Characteristics of dispersed campers.—Traditionally, outdoor camping has been associated with an opportunity for isolation from the rest of society and the complexities of daily life. In recent years, the addition of social activities and amenities at developed campgrounds has helped to change somewhat the type of people who camp at these areas. However, the traditional features of outdoor camping are still important to a large number of people, and dispersed camping offers this kind of experience.

For example, 28 percent of campers in a Pacific Northwest study felt that getting completely away from others was very important.[33] Although 67 percent of campers preferred to camp in developed campgrounds, 14 percent preferred undeveloped sites and 16 percent liked back country or wilderness.

About one-third of the camping activity in the summer of 1972 occurred in remote or wilderness settings (table 13). This percentage has remained about the same since the first national survey in 1960.[34] Similarly, on National Forest lands, about one-third of the camping occurred away from developed sites (table 15).

Projected demand for dispersed camping.—The demand for camping in dispersed areas is closely tied to demand for other activities. Fishermen, hunters, mountain climbers, hikers, horseback riders, and berrypickers commonly participate in dispersed

To many, backpacking into wilderness areas provides an opportunity for isolation from society and the complexities of daily life.

camping. However, dispersed camping is probably growing fastest in association with backpacking and roadside camping. The increased participation in backpacking has been stimulated by the development of lightweight equipment, freeze dried foods, the extension of the season of use due to the development of improved equipment and techniques. Roadside camping has increased with the growing popularity of recreation vehicles, especially at choice locations such as forest openings or along streams or lakes where it is possible to get off the road.

On the basis of these expectations, and given the medium projections of population and income growth, the demand for dispersed camping is projected to increase 90 percent by the year 2020 (table 17). Under alternative assumptions on growth in population and income, the projected demands in 2020 range from an increase of 55 percent to 108 percent.

Supply of dispersed camping.—The supply of dispersed camp spots is not easily analyzed, but research has shown that certain types of locations have greater appeal than others. For instance, a study of dispersed camping on forest roads was conducted by the Forest Service during the summer of 1974 on four road systems of the Snoqualmie National Forest in Washington and two road systems of the Des-

[33] Clark, Roger N., John C. Hendee, and Frederick L. Campbell. Values, behavior, and conflict in modern camping culture. Journal of Leisure Research 3(3):143–159. 1971.

[34] Outdoor recreation for America. Report to the President and Congress. op. cit.

chutes National Forest in Oregon. This study showed that a large number of informal dispersed recreation sites had been established by recreationists (table 26). Many of these sites were in clearings resulting from timber harvest, such as old landings, turnouts, spur roads, and passable skid trails.

The study also indicated that use of the roads for camping during the week was minimal, and that heavy use occurred on weekends. If the findings from this study are indicative of the situation on the more than 200,000 miles of Forest Service roads, then dispersed recreation use is substantial and there are many potential sites for this type of activity.

Opportunities for increasing dispersed camping sites.—A wide variety of opportunities exist along forest and range roads to provide dispersed camping spots. In construction of roads, it would be possible to provide additional locations where vehicles can leave the roadway.

At present, exit points often exist where logging roads intersect the permanent road system. In these cases, short sections of the logging road could be left open to provide campsites. In designing future roads, care could be taken not to eliminate potential campsites near riverbeds, scenic vistas, or meadows. Similar opportunities exist in back-country areas.

As for all other activities, there is a capacity for dispersed camping which should not be exceeded. Dispersed recreation use cannot be increased substantially in many areas without causing problems such as increased fire danger, resource deterioration, and public health and sanitation problems.

The Demand and Supply Situation for Nonmotorized Recreation Travel

According to the Bureau of Outdoor Recreation's National Recreation Survey in 1972, approximately 64 million Americans 12 years or older walked for pleasure, 34 million took nature walks, 20 million bicycled, 12 million went horseback riding, and 12 million hiked with a pack in the summer.[35] Wintertime activities such as cross-country skiing and snowshoeing are also growing in popularity, but no statistical estimates are available on the number of people participating. Most of these activities are appealing because of their simplicity and lack of need for expensive equipment.

Characteristics of participants in nonmotorized travel.—People generally seem to prefer day outings when participating in these activities. For instance, in recent studies in eight wilderness and back-country areas in Montana and Idaho, over half of all hiking parties come back the same day they went in. Less than one-tenth stayed more than two nights.[36] In these studies, and others, the typical hiker was usually on a one-day outing and has traveled no more than a few miles from home. In a 1970 study of Appalachian Trail users, more than 50 percent were on one-day excursions.[37] It was found, however, that

[35] U.S. Department of the Interior, Bureau of Outdoor Recreation. The 1970 survey of outdoor recreation activities. Government Printing Office. Washington, D.C. 1972.

[36] Robert C. Lucas. Forest Service. Wilderness research in the Rockies. Western Wildlands. Spring 1974.

[37] Murray, J. B. Appalachian trail users in the southern National Forests. U.S. Department of Agriculture Forest Service Res. Pap. SE-116. 19 p. 1974.

Table 26. *Dispersed camping sites on six road systems on the Snoqualmie and Deschutes National Forests, summer 1974*

Road system	Road length	Sites inventoried	Density (sites per mile)
	Miles	*Number*	*Number*
Snoqualmie National Forest			
North Fork of the Snoqualmie	15	35	2.3
Middle Fork of the Snoqualmie	30	75	2.5
Huckleberry Creek	36	40	1.1
Greenwater	64	128	2.0
Deschutes National Forest			
Deschutes River (Bend District)	178	100	0.56
Abbott Creek Patrol Route (Sisters District)	140	90	0.64

Source: Hogans, Mack. *Public use of forest roads pilot study. summer 1974, Snoqualmie National Forest: North Bend and White River Ranger Districts.* Recreation Research Project, Pacific Northwest For. and Range Exp. Sta., Seattle, Wash. (Unpublished.)

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Over half of all hikes into wilderness and back-country areas last only a day.

the amount of experience in hiking had a bearing on the length of the trip. A higher percentage of hikers in low experience-levels were on one day hikes than those in moderate to high experience-levels.

The two main factors that seem to influence participation in these activities are income and age. Individuals from households in the low income bracket account for the largest number of participants. However, by percentage, these people participate less than their proportionate share of the population. This is no doubt due to their lack of mobility coupled with the relative scarcity of trails near major population centers.

Young people participate to a greater extent in the more physically demanding of these activities. Participation gradually drops off as age increases. For example, Forest Service studies indicate that 50 percent of backpackers are under 30 years of age.

Projected demand for nonmotorized travel.—All types of nonmotorized activities are projected to grow (table 17). For most activities, the projected increases (medium level) to 2020 range between 60 and 80 percent. As a result of the recent boom in bicycling, the largest projected rise (126 percent) is for this activity. As with other outdoor recreation activities, the alternative population and economic assumptions have significant impacts on projected demand in the decades after 1990. Many nonmotorized activities could show faster growth if energy costs increase more than anticipated.

Supply of facilities for nonmotorized travel.—Trails are often essential to the enjoyment of nonmotorized recreation travel. However, much of this use occurs on roads or in undeveloped areas:[38]

[38] Forest Service estimates.

	Roads (*visitor days*)	*Developed recreation sites* (*visitor days*)	*Trails* (*visitor days*)	*General undeveloped areas* (*visitor days*)
Hiking	948,100	123,400	5,187,000	2,058,700
Horseback riding	650,300	19,600	1,281,400	863,800
Cross-country skiing	7,800	.....	26,500	313,500
Bicycling	261,700	4,500	28,200	3,300

Most of America's trails are in the West. These were established from travelways used by Indians, cattle drivers, frontiersmen, prospectors, hunters, ranchers, sheepherders, and loggers. Early land managers added to this network to protect and manage the forest and range resources. Comparatively few trails in the West have been planned and built with the recreationist specifically in mind.

Many trails have been replaced in recent years by road networks. In 1944, the National Forest System contained over 150,000 miles of trails. By 1965, only 73,270 miles of these trails were maintained for public recreation use (table 27). Another 29,429 miles of trails exist in other Federal and State ownerships. In addition, as indicated in the tabulation below, there were 143,800 miles in private, county, and municipal ownerships.[39]

Ownership	*Foot* (*miles*)	*Horse* (*miles*)	*Bicycle* (*miles*)	*Total* (*miles*)
Private	63,100	63,500	10,000	136,600
County	700	300	200	1,200
Municipal	3,900	1,300	800	6,000
Total	67,700	65,100	11,000	143,800

One of the most significant pieces of legislation affecting trails was the National Trails System Act

[39] U.S. Department of the Interior, Bureau of Outdoor Recreation. Trails for America. Government Printing Office. Washington, D.C. 155 p. 1966.

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Many trails, now used for outdoor recreation, were travelways established by indians, frontiersmen, propectors, cattle drivers, and loggers.

passed by Congress in 1968. It provides for National Scenic Trails, National Recreation Trails, and connecting and side trails. As indicated in the preceeding chapter of this study, two scenic trails have been established—the Appalachian Trail with 2,050 miles and the Pacific Crest Trail with 2,594 miles. To date, 67 National Recreation Trails have also been established. These range in length from just under one-fourth mile to about 67 miles and cover a total of 515 miles.

Opportunities for developing additional facilities for nonmotorized travel.—There are many opportunities to extend the use of forest and range lands by mapping, logging, cataloging, and marking existing trails and making this information available to the public. A similar effort for cross-country ski and snowshoe trails would help to meet the growing demand for these activities. These uses may coincide with trails designed for summer use but more often use roads closed by snow. New trails can be built where now lacking or inadequate. The construction and improvement of trails for short hikes near urban centers provides potential solutions for problems in existing areas.

While the surge in demand for bicycling is satisfied to a large extent on city streets and trails in urban areas, there is a corresponding increase in this activity in rural and natural environments. Consequently, bicyclists are found in more and more campgrounds, and along forest highways and trails. The main task facing public agencies is the identification of potential bicycle travelways and relating these to the demand in a particular locale. The Bureau of Outdoor Recreation and several States have already recognized the potential of abandoned railroad grades as bicycle trails. Where topography permits, many trails are being modified to be used for bicycling. An example is the California Aqueduct Trail which may eventually be part of a Canada to Mexico trail along the West Coast, serving a variety of uses including cycling.

The Demand and Supply Situation for Motorized Recreation Activities

Perhaps no single technological advance has had a more pronounced effect on the use of forest and range land for outdoor recreation than the improvements in the characteristics and performance of off-road vehicles during the 1960's. Prior to that time, off-road vehicles (motorcycles, all-terrain vehicles, four-wheel drives, and snowmobiles) were very heavy and expensive to operate and repair. This situ-

Table 27. *Trail mileage in the United States in Federal and State ownership, by major use and administering agency, 1965*

Administering agency	Total[1]	Foot	Horse	Bicycle	Trail scooter
Forest Service	73,270	73,151	63,404	4,145	23,649
Park Service	9,216	7,814	7,229	232	0
Bureau of Land Management	3,602	2,559	2,894	150	555
Fish & Wildlife Service	23	23	17	0	0
Indian Service	1,636	1,599	1,605	0	53
Bureau of Reclamation	87	87	77	2	2
States	14,865	12,420	4,234	354	1,131
Total	102,699	97,653	79,459	4,883	25,390

[1] Totals are not the sum of individual uses because most trails sustain more than one means of travel.

Source: U.S. Department of the Interior, Bureau of Outdoor Recreation. *Trails for America*. Government Printing Office, Washington, D.C. 155 p. 1966.

ation changed dramatically with development of dependable lightweight motorcycles and snowmobiles. U.S. sales of these vehicles increased from an average of 155,000 units in 1960–62 to over 1 million in 1974. Sale of other off-road vehicles probably followed a similar upward trend.[40]

No accurate figures are available to indicate how many off-road vehicles are presently in use. But estimates furnished by the Motorcycle Industry Council and International Snowmobile Industry Association provide an insight into the approximate number. A nationwide survey conducted by the Motorcycle Industry Council indicated there were 7 million motorcycles used in the United States in 1974. Of these, 904,000 were off-road vehicles and 2.9 million were designed for both on- and off-road travel. The International Snowmobile Industry Association estimates that there were about 1.7 million snowmobiles in use for the 1974–75 season. In addition, it was estimated that in 1972 there were about 200,000 dune buggies and 50,000 all-terrain vehicles in use.[41]

[40] Stupay, Arthur M. Growth of powered recreation vehicles in the 1970's. Proceedings of the 1971 Snowmobile and Off the Road Vehicle Research Symposium. Michigan State University, College of Agriculture and Natural Resources, East Lansing, Mich. Technical Report No. 8. August 1971.

[41] Hope, Jack. The invasion of the awful ORV's. Trends, a publication of the Park Practice Program, 9(3):15. 1972.

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Nearly 2 million snowmobiles are in use in the United States. Many National Forests and other lands in public ownership have designated trails and areas for the use of these and other types of off-road vehicles. This controlled use is necessary to protect the environment and the interests of other users.

Purchases of most off-road vehicles have dropped off in recent years. The Motorcycle Industry Council reports that shipments from the top six manufacturers, which accounts for about 95 percent of the sales, were as follows:

	On road (number)	*Off road (number)*	*Dual purpose (number)*	*Total (number)*
1972	510,000	212,000	510,000	1,232,000
1973	617,000	274,000	539,000	1,430,000
1974	453,000	225,000	431,000	1,109,000

A similar trend was reported by the International Snowmobile Industry Association which estimated retail snowmobile sales:

1972 . . . 460,000

1973 . . . 450,000

1974 . . . 435,000

Projected demand for motorized outdoor recreation.—Although recent purchases for most off-road vehicles have dropped, this is probably due to a short-term decline in economic activity and income. The anticipated long-run growth in population, income, and leisure time suggests that the demand for off-road vehicles is likely to rise again. Accordingly, it is projected that off-road driving will increase about 70 percent by 2020 and motorcycling 54 percent (table 17). The difference is caused by the close association of motorcycling with the youth market which is expected to decline in relative importance in the coming decades. The projected increase for other off-road vehicles is about equal for other outdoor recreation activities. Under the alternative population and economic assumptions, projected increases to the year 2020 vary from a low of 32 percent for motorcycling to a high of 109 percent for other off-road vehicles.

Supply of facilities for motorized outdoor recreation.—Much of the forest and range land close to urban areas that is suitable for off-road vehicle travel is privately owned. Most of this land is not open to the general public for off-road vehicle use. Snowmobile organizations have made substantial progress in acquiring trails for their use, but other groups have not been as successful.

Off-road vehicle travel is an acceptable use of portions of Federal lands, and agencies are designating lands and trails for this use.[42] As of July 1, 1974,

[42] U.S. Department of the Interior, Bureau of Outdoor Recreation. ORRV. Nov. 1971.

National Forest lands and trails were tentatively classified for use as follows:

Land:	*Thousand acres*
Open to off-road vehicle use year round	157,704
Closed to off-road vehicle use seasonally	1,835
Closed to off-road vehicle use year round	13,835
Trails:	*Miles*
Open to off-road vehicle use year round	87,207
Closed to off-road vehicle use seasonally	1,556
Closed to off-road vehicle use year round	7,407

Other Federal agencies are also studying the lands they administer for use by off-road vehicles. The Bureau of Land Management, which manages the most Federal lands available for off-road vehicles use, is presently zoning its land in a method similar to that being used by the Forest Service. Similar studies are underway on National Parks, Monuments, and Historic Sites. The Park Service allows snowmobiles to use designated trails in some parks.

Opportunities for increasing areas for off-road vehicle use.—Increasing the areas available for off-road vehicle use presents special problems because of the need to protect the environment and rights of other recreationists.

Much of the criticism of off-road vehicles stems from damage to the environment, and esthetic pollution such as noise. Although several studies have dealt with environmental effects, no conclusions have been reached regarding the long-range effects.[43] However, the potential for damage to the environment is recognized, and lands are being managed in ways which will maintain and protect the environment.

As indicated earlier, much of the land suitable for off-road vehicle use is privately owned, principally farms and woodlots near urban centers. Since an increasing proportion of off-road vehicle owners live in urban areas, the private lands could satisfy much of the demand for this kind of recreation opportunity. Yet, many of these lands are not available to such users. Damage to property, harassment of livestock, and poor manners by some users have caused many landowners to close their property to off-road vehicles. Some off-road vehicle groups have formed clubs or other formal organizations to work with private landowners in an effort to make more of these lands available. An expanded effort is needed in order to help provide areas for this kind of recreation where they are most needed. Some of the things which might help to achieve this include: (1) compensate the landowner for rights-of-way, (2) absolve the landowner of liability for damage or injury to users of his property, (3) provide insurance to pay for damage caused by users, (4) educate potential users on the need to adopt a proper "use ethic," (5) adopt stronger law enforcement measures and tie these to expanded self-policing by user groups, and (6) license and register of vehicles to help with finance, improvements, use regulation, and identification.

Another possibility for meeting future demands for off-road vehicle travel is to adopt travel corridors which contain trails for various user groups. In recent years, some thought has been given to establishing all-use trails which would serve snowmobiles in the winter and motorcycles in the summer, as one example.

The Demand and Supply Situation for Boating and Canoeing

An extensive national survey of ownership of boats and canoes was recently completed for the U.S. Coast Guard.[44] This survey revealed that there were approximately 8.3 million boats of all kinds in 1973. The general breakdown is as follows:

Boat type	*Number (thousands)*	*Percent*
Outboard	4,420	53.0
Rowboat/jonboat	1,222	14.7
Inboard	561	6.7
Inboard/outboard	527	6.3
Sailboat	524	6.3
Canoe	496	5.9
Inflatable	51	0.6
Houseboat	39	0.5
Kayak	37	0.5
Other	459	5.5
Total	8,336	100.0

The survey revealed substantial regional differences in the types of boats owned. Residents of New England, Middle Atlantic, and the Great Lakes States owned 76 percent of the canoes and 92 percent of the canoes with motors. The combined areas of New England, Middle Atlantic, and West Coast contained 93 percent of the kayaks and 74 percent of the sailboats. Residents of the Middle Atlantic, Gulf Coast, and East Central States owned 63 percent of the jonboats.

The survey also showed that the average boating household spent 47 percent of its time engaged in fishing, 32 percent cruising or sailing, and 12.4 percent water skiing. There was, however, some re-

[43] U.S. Department of the Interior, Bureau of Outdoor Recreation. Off-road recreational vehicles. 1971; and Lodico, Norma Jean. Environmental effects of off-road vehicles. U.S. Department of the Interior, Office of Library Services. 1973.

[44] Wulfsberg, R. M., and D. A. Lang. Recreational boating in the continental United States in 1973: a nationwide boating survey. Department of Transportation, United States Coast Guard, Washington, D.C. 104 p. 1974.

Table 28. *Percentage distribution of household boating in the contiguous States, by type of activity and region, 1973*

Region	Cruising/ sailing	Water skiing	Recreational fishing	Hunting	Racing	Commercial use	Other
New England	45.7		38.1	0.4	1.7	2.3	4.0
Middle Atlantic	32.9	7.7	45.3	1.6	2.6	1.5	8.4
Gulf Coast	19.4	9.7	58.6	2.5	0.3	2.7	6.8
East Central	28.7	11.4	47.8	1.8	0.2	1.0	9.1
Great Lakes	31.8	11.7	50.3	1.2	0.6	0.7	3.7
Midwest/Mountains	25.8	16.6	45.2	1.6	0.5	0.4	9.9
West Coast	32.8	16.2	36.4	1.6	2.4	1.2	9.4
Total	31.6	12.4	46.5	1.5	1.2	1.5	5.3

Source: Wulfsberg, R. M., and D. A. Lang. *Recreation boating in the continental United States in 1973: a nationwide boating survey.* Department of Transportation, United States Coast Guard. Washington, D.C. 104 p. 1974.

gional variation to these averages (table 28). For instances, residents of the Midwest, Mountain, and West Coast regions spent a higher percentage of time water skiing while Gulf Coast residents spent more time fishing.

Projected demand for boating and canoeing.—Although the sale of boats (such as motorboats) may fluctuate from year to year, the total number of recreational boats in use has tended to increase steadily from 1962 to 1974 (table 29).[45]

[45] Marketing Department of Marex and the National Association of Engine and Boating Manufacturers. Boating 1974. Chicago, Ill., and New York, NY. 1974.

Boating has also been increasing on the National Forests. In 1974, boating comprised 3 percent of the total recreation use of the National Forest System, up from 2 percent a few years earlier. It ranked ninth in popularity among activities. Powerboating accounted for 64 percent of the total use, while canoeing, rafting, sailing, and other nonpower boating activities comprised 36 percent. Nonpower boating has been increasing at a much faster rate, and may become the most popular with National Forest visitors during the 1980's.

Demands for boating, canoeing, and related activities are projected to show fairly rapid growth in

Table 29. *Annual sales of boats, motors, and trailers in the contiguous States, 1963–74*

Year	Motor unit sales	Average horsepower for motors sold	Outboard motors owned	Outboard boats sold	Inboard/ outboard boats sold	Boat trailers sold
1963	362,000	30.5	6,390,000	245,000	8,000	148,000
1964	390,000	30.3	6,564,000	250,000	12,000	130,000
1965	393,000	28.2	6,645,000	250,000	17,000	130,000
1966	440,000	29.9	6,784,000	266,000	32,000	153,000
1967	440,000	30.1	6,904,000	260,000	36,000	160,000
1968	500,000	31.5	6,988,000	283,000	42,000	200,000
1969	510,000	33.1	7,101,000	310,000	49,000	235,000
1970	430,000	31.0	7,215,000	276,000	43,000	213,000
1971	495,000	35.6	7,300,000	278,000	44,000	220,000
1972	535,000	38.1	7,400,000	375,000	63,000	265,000
1973	585,000	40.8	7,510,000	448,000	78,000	330,000
1974	545,000	40.5	7,595,000	425,000	70,000	325,000

Source: Marketing Department of Marex and the National Association of Engine and Boat Manufacturers. *Boating 1974.* Chicago, Ill., and New York, NY. 1974.

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The demand for sailing is projected to quadruple. Existing facilities on inland waters will have to be greatly expanded if this demand is met.

the decades ahead (table 17). Sailing increases especially fast, more than quadrupling by 2020 under the medium assumptions about growth in population and income. The alternative assumptions on population and income significantly affect the demands for the various forms of boating and canoeing in the decades beyond 1990.

Supply of boating and canoeing facilities.—The Bureau of Outdoor Recreation has developed an inventory of surface water areas suitable for boating and fishing for the Water Resource Council. Estimates show that 22.6 million acres of public water were available for boating, sailing, and water skiing in 1975 (table 30).

The increasing popularity of boating and canoeing is causing conflicts with other uses in many parts of the country. In Michigan, for example, there are several rivers which are very high quality trout fishing streams, but the canoeing use on weekends has increased to the point where there is literally a steady stream of canoes, and fishermen have found it almost impossible to fish. Floating on the Middle Fork of the Salmon River in Idaho has increased to the point where the Forest Service has found it necessary to issue permits limiting the number of people who can use the river at a given time.

In many locales, administrators have found it necessary to adopt special rules and regulations for powerboating. Most States in the Midwest have found it necessary to limit the time of day that motorboats may be operated on some lakes in order to assure fishermen that they can enjoy a reasonably safe and productive fishing experience. There are numerous other situations where waters have been zoned to provide or to limit various boating activities.

Opportunities for increasing supplies of boating and canoeing facilities.—As indicated in the introductory chapter of this study, the Nation has a huge inland water resource. However, most of the shorelines are in private ownership and access to existing waters is limited. Expanded access through public ownership or right-of-way easements is the best opportunity to increase and extend the area of water available for boating, canoeing, and related activities. This is particularly desirable in densely populated areas where access to water tends to be tightly controlled and in locations where waterways are limited in number or size.

Water areas suitable for boating and canoeing can be increased by controlling pollution, and in streams, by removing obstacles to movement and maintaining suitable water levels. Reservoirs and ponds may be constructed, however, this must usually be justified on other grounds such as flood control or to develop and maintain water supplies for domestic, agricultural, and industrial uses.

Table 30. *Estimated public supply of surface water for boating, sailing, and water skiing, by water resource region, 1975*

(*Acres*)

Water resource region[1]	Boating, sailing and water skiing	
	Surface water[2]	Parking[3]
New England	1,450,000	320
Middle Atlantic	1,804,000	422
South Atlantic-Gulf	2,029,000	682
Great Lakes	4,253,000	2,310
Ohio	519,000	714
Tennessee	525,000	165
Upper Mississippi	753,000	470
Lower Mississippi	420,000	175
Souris-Red-Rainy	333,000	30
Missouri	2,827,000	624
Arkansas-White-Red	634,000	465
Texas—Gulf	387,000	257
Rio Grande	69,700	14
Upper Colorado	329,000	42
Lower Colorado	209,000	199
Great Basin	1,513,000	58
Columbia—North Pacific	1,513,000	740
California—South Pacific	1,091,000	471
Alaska	1,937,000	52
Hawaii	1,500	0
Total	22,597,200	8,210

[1] See Water Assessment Chapter, Figure 36, for a map of regions.

[2] Water available and useful for recreation. To be available and useful, the water must have adequate access by the public, be free of obstruction to its use, and be of suitable quality for recreational use. This does not include some waters which may have incidental recreational use.

[3] Available for all boating, sailing, and water skiing.

Source: U.S. Department of Interior, Bureau of Outdoor Recreation. *75 Water Assessment.* May 1975.

Wilderness

The word "wilderness" has different meanings for different people.[46] However, for the purposes of this study, the definition contained in The Wilderness Act of 1964 (PL 88–577) and subsequent legislation will be used.

The Wilderness Act defined Wilderness as:

> A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recongized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has out-

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"Wilderness areas must have outstanding opportunities for solitude . . ."—The Wilderness Act.

[46] Nash, Roderick. Wilderness and the American mind. Revised edition. Yale University Press. 1973.

standing opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

The primary purpose for establishing a National Wilderness Preservation System was set forth as: "In order to assure that an increasing population, accompanied by expanding settlement and growing mechanization does not occupy and modify all areas within the United States and its possessions. . ." The Act also specified that administering agencies are ". . .responsible for preserving the wilderness character of the area and shall so administer such area for such other purposes for which it may have been established as also to preserve its wilderness character."

The National Wilderness Preservation System

The first formal designation of a Wilderness area was made by the Forest Service in 1924 on the Gila National Forest in New Mexico. In the next 40 years, additional areas were set aside in National Forests to preserve their wilderness or primitive values.

By the time the Wilderness Act was passed in 1964, the Forest Service had established 54 areas (Wild, Wilderness, or Canoe Areas) totaling 9.1 million acres. These areas were accepted as the nucleus of the Wilderness System. In addition, the Act directed that 34 Primitive Areas on the National Forests be studied for possible inclusion in the System. The Secretary of the Interior was also directed to review all roadless areas and roadless islands over 5 thousand acres in size administered by the National Park Service and Fish and Wildlife Service and make recommendations to the President and to Congress on their suitability or nonsuitability for inclusion in the Wilderness System.

Between the passage of the Wilderness Act and July 10, 1975, 71 areas totaling 3.3 million acres were added to the System raising the total to 12.3 million acres (table 31). About 93 percent of this area was administered by the Forest Service, 5 percent by the Fish and Wildlife Service, and 2 percent by the National Park Service. Wildernesses account for approximately 5 percent of the lands administered by these agencies.

Of the 54 areas originally set aside as Wildernesses, only 4 were in the eastern United States. The East/West imbalance in Wildernesses has continued, although Congress recently added 16 areas in the East, encompassing 207 thousand acres, to the System (PL 93–622). Still, only about 13 percent of the designated Wilderness acreage is located east of the Rocky Mountains, and over half of this is in the Boundary Waters Canoe Area of northern Minnesota. However, there are eastern areas with true wilderness character owned by State and local governments and private landholders.[47] Three noteworthy examples of State-owned tracts are the Adirondack (997,600 acres) and Catskill (91,000 acres) State Parks in New York and Baxter State Park (201,018

[47] For a complete listing see:
National Geographic. Wilderness U.S.A. National Geographic, Washington, D.C. (3rd ed.). 344 p. 1975.

Table 31. *Status of National Wilderness Preservation System in the United States, July 10, 1975*

Classification	Total		National Forest System		National Park System		National Wildlife Refuge System		Bureau of Land Management[1]	
	Number	Million acres	Number	Million acres	Number	Million acres	Number	Million acres	Number	Million acres
Gross acres administered	.....	696.8	....	187.0	....	29.1	....	30.7	....	450.0
Areas classified as Wilderness by 1964 Act	54	9.1	54	9.1	0	0	0	0	....	.....
Areas classified as Wilderness since 1964 Act	71	3.3	31	2.5	4	0.2	36	0.6	....	.....
Total classified as Wilderness	125	[3]12.3	85	11.6	4	0.2	36	0.6	[2](6)	[2](0.15)
Proposals submitted to Congress but not yet approved	112	26.1	21	3.8	41	14.8	50	7.5	....	.....

[1] Bureau of Land Management lands not included in 1964 Wilderness Act.

[2] Administratively classified as primitive areas.

[3] Columns may not add to totals because of rounding.

acres) in Maine. These are of special importance in providing wilderness type recreation to the people on the eastern seaboard.

Recreational Use of Wilderness

Outdoor recreation use is the most common wilderness use. There are, however, other important uses (see discussion below) which have implications for Wilderness management and for assessment of demands for future Wildernesses.

In 1974, the National Forest Wildernesses received 5.7 million visitor days of use. Recreation use on National Park and National Wildlife Refuge Wildernesses amounted to another several hundred thousand visitor days. In addition, there was close to 5 to 6 million visitor days of use on the areas under study for possible Wilderness classification. This included 1.1 million days of use on National Forest areas, 3 to 4 million on National Park areas and about 0.5 million on National Wildlife Refuge areas.

Recreational activities such as hiking and backpacking are the most common use of Wilderness.

Wilderness recreation use must be low density if unmodified natural conditions are to be protected and if "outstanding opportunities for solitude," as described in the Wilderness Act, are to be maintained. Present use of National Forest Wilderness amounts to about one-half of a visitor day per acre. Informed judgments by Wilderness managers of different areas with varying use pressures suggest this average may be close to a desirable upper limit on some Wildernesses. Carrying capacity, however, is influenced by many factors such as length of season, number of access points, abundance of trails or other travel routes, numbers of camping areas, attractions, fragility or durability of soils, vegetation, and location relative to densely populated areas.

The intensity of Wilderness recreation use varies greatly from Wilderness to Wilderness. Two National Forest Wildernesses each had over one million visitor-days use in 1974—The John Muir Wilderness in California and the Boundary Waters Canoe Area in Minnesota. Some other Wildernesses had only a few thousand visitor days of use. Visitor days per acre varied from a high of about 5 to a low of about 0.01—a 500 to 1 ratio. Even allowing for all of the variation in capacity, it is clear that some Wildernesses are overused, and some especially with effective management, could accommodate more use.

Recreational use is also typically very unevenly distributed within individual Wildernesses. A small proportion of access points and travel routes usually account for most use. For instance, in several Wilderness studies, it was found that travel was often concentrated on one-tenth of the trail system. This poses a management challenge, to try to redistribute use more in keeping with area capacity, but it also has implications for the need for additional Wilderness. If improved management can increase recreational use while protecting wilderness qualities, fewer acres can meet given increases in demand.

The most heavily visited Wildernesses areas are those located relatively close to large population centers. This suggests that possible future additions to the Wilderness System would serve recreational needs better near centers of population. It could also be interpreted as an indication of regional needs for other non-Wilderness types of primitive recreation.

The need for intensified management of visitor use in the heavily used Wildernesses is great. Some National Park Wildernesses and 4 National Forest Wildernesses have limits on use. Other areas will probably be forced to limit use, although alternative management actions involving efforts to inform and educate visitors might shift use patterns and improve wilderness skills enough to reduce impacts and avoid or postpone these controls. Research indicates that most visitors, even in heavily used Wildernesses, consider solitude an important wilderness characteristic and support controls on use when needed. However, studies of Wilderness visitors suggest a substantial proportion, perhaps a fourth to half, of the recreationists who now visit Wilderness would find what they are seeking as well or better in a non-Wilderness, roadless recreation area.

Trends in recreation use of Wilderness.—Wilderness recreational use has outpaced the overall rate of growth for outdoor recreation since the first National Forest recreation estimates were released over 30 years ago. Total visits to National Forest Wildernesses have increased about 15-fold since World War II and National Park areas have had

similar large increases. However, the annual rate of growth has been falling. Prior to 1960, the annual average increase on National Forest areas was 15 percent—some 3 times the 5 percent average of the early 1970's. At the present time, Wilderness accounts for 3.5 percent of all National Forest visitor days.

The character of Wilderness recreation use has also been shifting. Backpacking, a popular family activity, has surpassed horseback riding and packing in growth. Similarly, in the Boundary Waters Canoe Area, visitors who paddle canoes have increased faster than those who use outboard motors on boats and canoes. The proportion of visitors who go on do-it-yourself trips in contrast to outfitted and guided trips have grown to a majority everywhere data are available.

Research has shown that Wilderness visitors are overwhelmingly urban. In addition, these studies show that (1) Wilderness visitors have high education levels, (2) most are white-collar workers, primarily in the social service and educational occupations, and (3) are somewhat above average in income. Young adults are the most common users, although both children and older adults are fairly well represented. This segment of the population grew enormously in the last 30 years, but as indicated above, will decline in numbers in the decades immediately ahead.

Projected recreational demand for Wilderness.—These trends in use, and the rather substantial increases assumed in population and income in the coming decades, suggest that recreational demands on Wilderness are likely to continue to increase. In the past, only two quantitative projections of Wilderness recreational use have been made. The Outdoor Recreation Resources Review Commission projected Wilderness man-days of use in the year 2000 to be 9.6 times the 1959 level.[48] Unpublished planning projections by the Forest Service for essentially the same period projected about the same increase. If actually realized, this would mean slightly less than a 6 percent annual increase, which is below the actual average annual change from 1960 to 1974. In this study, it has been assumed that recreational use of Wilderness will rise roughly in line with the demand for remote camping—an activity that is projected to increase 80 percent by 2020.

Nonrecreational Uses of Wilderness

Although outdoor recreation is the common use of Wilderness, there are other important Wilderness uses and values. Several research studies have shown that many people enjoy wilderness vicariously, rather than onsite.[49] Some of these people have made, or will make, onsite visits and value the option to visit Wildernesses; others never set foot in Wilderness, but value its existence.

Other important uses include scientific, educational, therapeutic, cultural, and in some Wildernesses, certain permitted commodity uses such as grazing, mining, and water storage. Ecologists, biologists, and scientists in other related fields use Wilderness as a natural laboratory. The contrast between the essentially altered ecosystems found in most other places helps scientists understand each kind of system better.

The relatively large size of most Wildernesses permit many ecological processes to work more freely and with less interference than in small Research Natural Areas. This is particularly important for some mammals with large ranges, such as grizzly bears and mountain lions, both of which have been studied in Wildernesses, and for some endangered species. In addition, Wildernesses also serve as a potential gene pool for indigenous species of plants and animals.[50]

Educational use is another of the Wilderness uses specified in the Wilderness Act. General data on this use are unavailable, but it clearly is substantial and growing, enough so that it may be a significant part of use pressures in a few places. A study of the use of Wilderness by 7 educational organizations in the Pacific Northwest estimated 13,000 visitor days of educational use of 8 areas in Washington and Oregon.[51] This accounted for about 5 percent of all use of several areas.

Other uses are part educational and part therapeutic. For example, Oregon mental hospital patients have been taken on Wilderness trips, with impressive success in patient improvement. Several studies have shown that the isolation and challenge

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[48] Outdoor Recreation Resources Review Commission. Wilderness and recreation problems. ORRRC Report No. 3, Washington, D.C. U.S. Government Printing Office. 1962.

[49] Fisher, Anthony C., John V. Krutilla, and Charles J. Cicchetti. The economics of environmental preservation: a theoretical and empirical analysis. American Economic Review 62(4):605–619. 1972; Tombaugh, Larry W. External benefits of natural environments. Recreation Symposium Proceedings. U.S. Department of Agriculture Forest Service, Northeastern For. Exp. Sta., Upper Darby, Pa. 1971; and Cicchetti, Charles J., and A. Myrick Freeman III. Option demand and consumer surplus: further comment. The Quarterly Journal of Economics Vol. 85, p. 528–539. 1971.

[50] Craighead, John J., Joel R. Verney, and Frank C. Craighead. A population analysis of the Yellowstone grizzly bears. Montana Forest and Conservation Exp. Sta., School of Forestry, Univ. of Montana. Bull. No. 40. 1974; and Hornocker, Maurice G. Mountain lion. Naturalist 22(3):27–32. 1971.

[51] Dick, R., J. Oltremari, D. Shapard, and A. Wilcox. Wilderness as a classroom—a preliminary report (unpublished report on file at Pacific Northwest For. and Range Exp. Sta., Seattle, Wash.). 1972.

of a Wilderness setting has beneficial effects on delinquent or disturbed young people.[52]

In addition, there are some uses that may be inconsistent with the special qualities of Wilderness, but which take place in Wilderness because of special provisions of the Wilderness Act. Mining is one of these uses. There are innumerable mining claims within the Wilderness System, and the Wilderness Act permits the staking of claims until the end of 1983.

Grazing and water storage are other uses permitted by the Wilderness Act. At present, there are 206,000 animal unit months (one animal unit month is equal to one cow or five sheep for one month) of grazing taking place in National Forest Wildernesses. Also, there are a number of small reservoirs for irrigation or streamflow regulation built before passage of the Wilderness Act. In addition, Wildernesses contribute to the maintenance of large areas of high-quality watersheds.

Snow storage is important use on high-elevation Wildernesses where heavy snow packs accumulate. Late season snow melts in such areas is important to summer streamflow. Because of this, weather modification in Wildernesses to increase snowpacks has been proposed, but generally is considered inconsistent with the primary wilderness objective of maintaining an ecosystem essentially unmodified by modern man.

While it is not feasible to quantify demands for nonrecreational uses of Wildernesses in any meaningful way, it does seem reasonable to assume that demands for most of these uses, as for recreation, are likely to increase fairly fast in the decades immediately ahead.

Opportunities for Meeting Future Demands for Wilderness

It is obvious that a large enough Wilderness System to meet all future demands for recreation and other uses cannot be established. It is also probably unrealistic to consider, as many suggest, that all currently undeveloped lands should be set aside as Wilderness to preserve future options.

There are, however, many opportunities for increasing the size of Wilderness areas. As of July 10, 1975, Congress was considering 112 proposals covering 26.1 million acres for inclusion in the Wilderness System. Forty-one of these proposals, with a total area of 14.8 million acres, concerned National Park System lands; 21 proposals, with an area of 3.8 million acres, concerned National Forest lands—the remaining 50 proposals involved 7.5 million acres of lands administered by the Fish and Wildlife Service (fig. 15).

In addition to the proposals before Congress, the Forest Service has scheduled for review 305 areas containing 13.2 million acres (fig. 15). The majority of these study areas are the result of an extensive study entitled the Roadless Area Review and Evaluation (RARE) conducted in 1972–73. The objective of this study was to identify areas most suitable for further study as possible additions to the National Wilderness Preservation System. The initial inventory produced a listing of 1,499 areas of some 56 million acres which were undeveloped.

The Park Service is studying 11 areas, eight of which are in the East. Study of wilderness potential has been expedited on nearly all of their 30 million acres.

In the future, the Bureau of Land Management may also make important contributions to the Wilderness System. The Wilderness Act of 1964 and subsequent Wilderness legislation exluded the 450 million acres administered by the Bureau of Land Management. Presently, the Bureau has 164 thousand acres designated as primitive areas in 4 western States. In addition to these areas, another 1.6 million acres (in 30 separate tracts) have been chosen as potential primitive areas in the West. The Bureau also administers vast areas in Alaska, most of which would be suitable for inclusion in the Wilderness System. However, a substantial part of this land is likely to be transferred to the State or to Alaskan natives. The Secretary of the Interior, under provisions of the Alaska Native Claims Settlement Act of 1971, has recommended that 83.5 million acres be used for National Parks, Forests, Wildlife Refuges, and Wild and Scenic Rivers. In his letter to the Speaker of the House of Representatives on December 17, 1973, the Secretary of the Interior indicated that the administering Federal agencies would review these lands and make recommendations on Wilderness study areas within 3 years after establishment.

In addition to adding new areas, other opportunities also exist for meeting future demands. Presently, much of the recreational use is concentrated on specific Wildernesses and on limited areas in Wilderness. Part of the future recreation demand could be met by spreading out the use. New trails and access points could be built and educational programs developed to inform and educate visitors about the opportunities. These measures would supplement the present programs to control user concentration

[52] Thorstenson, Clark T., and Richard A. Heaps. Outdoor survival and its implications for rehabilitation. Therapeutic Recreation Journal, Vol. VII, No. 1, First Quarter. 1973; Bernstein, Arthur. Wilderness as a therapeutic behavior setting. Therapeutic Recreation Journal, Vol. VO, No. 4. 1972; Kaplan, Rachel. Some psychological benefits of an outdoor challenge program. Environment and Behavior 6(1):101–116. 1974; and Hanson, Robert A. Outdoor challenge and mental health. Naturalist 24(1):26–31. 1973.

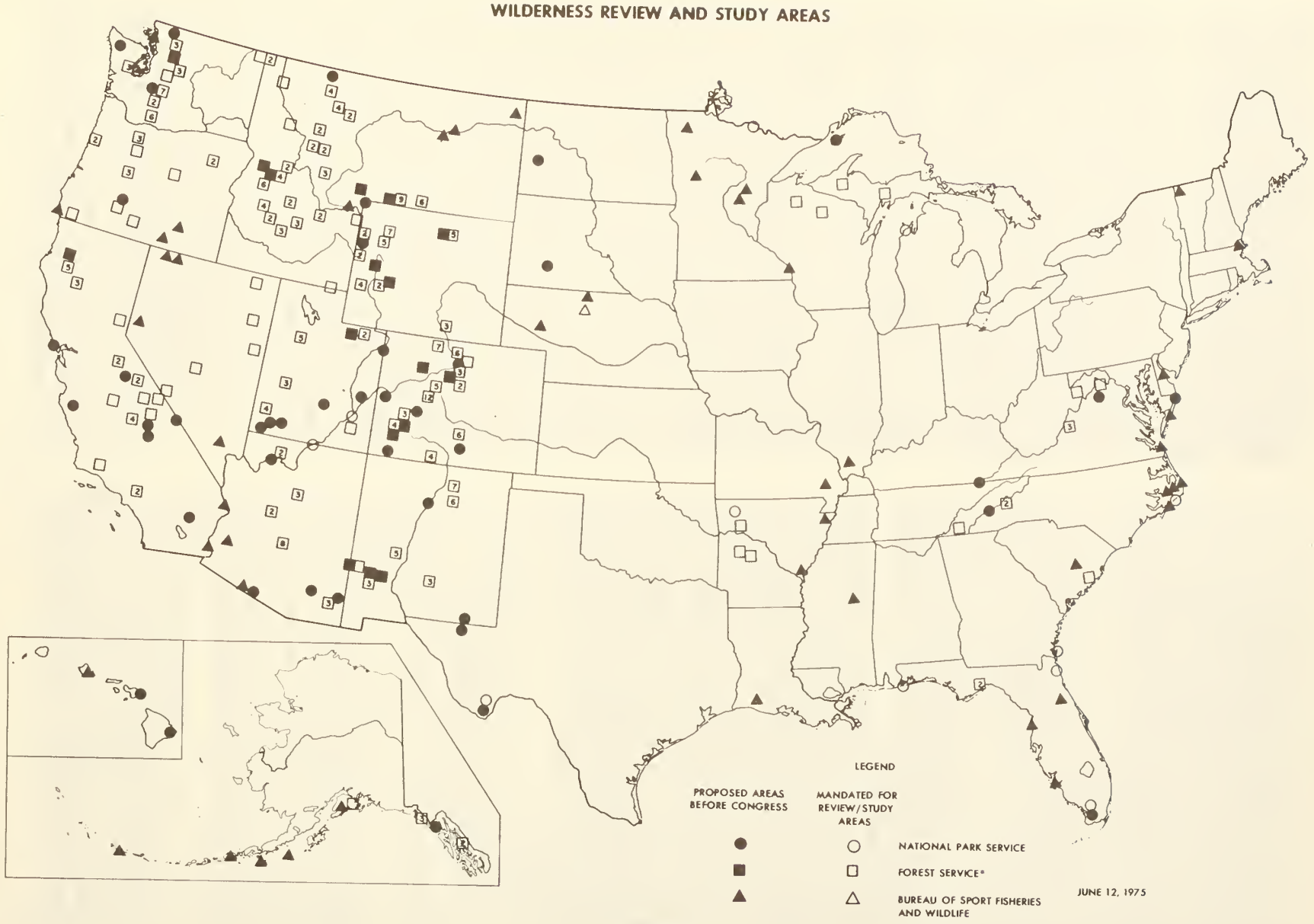
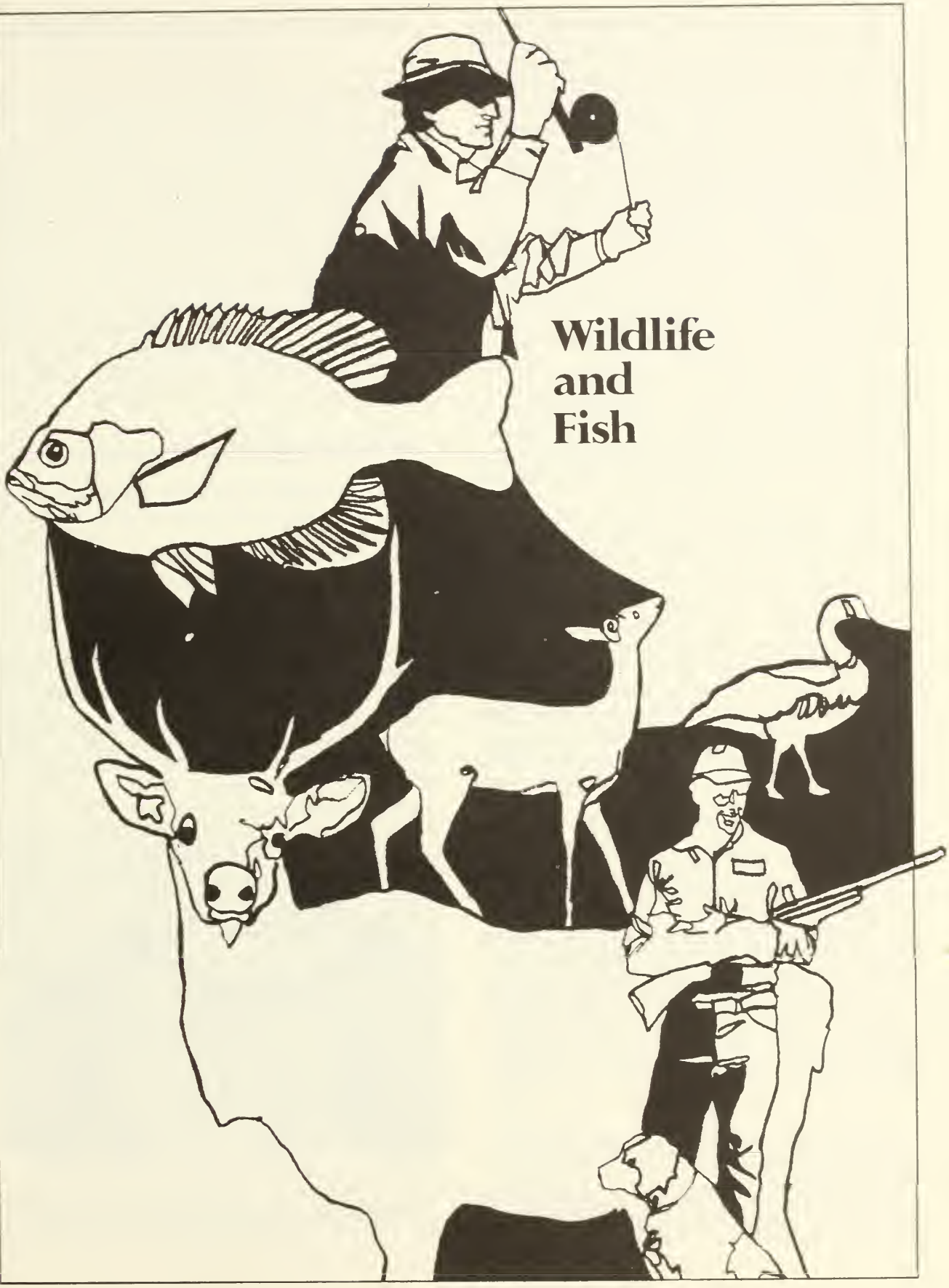

WILDERNESS REVIEW AND STUDY AREAS
LEGEND
PROPOSED AREAS BEFORE CONGRESS
MANDATED FOR REVIEW/STUDY AREAS
NATIONAL PARK SERVICE
FOREST SERVICE*
BUREAU OF SPORT FISHERIES AND WILDLIFE
JUNE 12, 1975

Figure 15

in the more popular areas. In addition, they would provide a broader range of Wilderness opportunities and minimize the erosion of the Wilderness qualities of the System as use grows.

Part of the demand for Wilderness could also be met by spreading use to non-Wilderness areas such as "back-country areas" or Research Natural Areas. A significant amount of the capacity of the Wilderness resource is being utilized for purposes that do not depend on the full combinations of Wilderness conditions such as large natural ecosystems, unmechanized travel, little or no development of recreation facilities, and low density recreation use. For instance, some fishing might be as enjoyable in a "back-country area" managed intensively for this purpose. Some research on plant communities also might be efficiently carried out in a Research Natural Area. Increased management programs could be implemented for non-Wilderness lands to provide improved opportunities for those uses while protecting the Wilderness qualities of the established system.


Wildlife
and
Fish

This chapter presents information on: (1) Trends in the use of wildlife and fish produced on forests, rangelands, and associated inland waters with projections of demand to 2020; (2) recent and probable trends in wildlife and fish populations; and (3) opportunities for improving forests, rangelands, and associated waters for wildlife and fish. This discussion covers three types of wildlife and fish populations: mammals and birds that are not hunted, those that are, and freshwater and anadromous fish.

Wildlife and fish populations are an integral part of the country's ecological systems and are a reflection of the health of the Nation's lands and waters.[1] These populations are also an integral part of the heritage of American people and it is for this reason, in large part, that interest in wildlife and fish is so high. Wildlife and fish and the habitats on which they depend for food, water, and shelter have sometimes been abused, a situation that has led to the extinction of some species. The growing interest and concern of the public has gradually brought about a greater appreciation of the values associated with wildlife and fish populations and has led to more enlightened management of these resources.

This report is the first that has assessed the wildlife and fish situation with a national perspective. Consequently, the basic data are uneven in quality, and some topics are treated primarily in qualitative terms. Consumptive demands are measured in terms of participants, and trends in game and fish populations are generally quantified in terms of harvests. Since the primary purpose is to define current and potential problem areas and the methods available to increase wildlife and fish populations, the direction of trends in demand and populations or habitat conditions are of greater importance than their precise levels.

In the following discussion, wildlife and fish populations are divided on the basis of the ways in which they are used by man. While this is convenient and best fits the available information, it is an artificial categorization. There are few areas in the United States that do not support a diversity of wildlife. Probably every hunted species is enjoyed as much for its strength or grace or craftiness as for the challenge it provides to the hunter. It is likely that hunters appreciate the role of wildlife in nature as much as anyone else.[2] Much of the material in the section on nonconsumptive uses is also directly relevant to game species.

[1] Ferguson, Dengel E. The new evolution. Environment 14 (6): 33. 1972; and National Wildlife Federation, 1971 EQ Index. National Wildlife 9 (6): 25–40. 1972.

[2] Wood, Donald B., and James J. Kennedy. Nonconsumptive use of a Utah elk herd. Outdoor recreation and tourism series, Utah State Univ., Logan, UT., 22 p. 1973.

Nonconsumptive Uses of Wildlife and Fish

All species of wildlife and fish that provide esthetic enjoyment for humans, including those of interest to hunters and fishermen, are the concern of this section. These species are watched and photographed and listened to; they are featured in children's books, in movies, and on postage stamps; and their very existence enriches the lives of everyone.[3]

In addition to being a source of direct enjoyment to people, many species of wildlife perform the vital function of helping to maintain stability in natural systems. Birds, for example, evolved with insects and in many instances are an important factor in insect population fluctuations. Such wildlife species are often critical links in natural food chains. Awareness of their importance has been increasing.

Characteristics of Nonconsumptive Users

A popular image of those who appreciate wildlife but do not hunt or fish, such as birdwatchers, is sometimes at striking variance with reality. Often viewed as the province of timid, frail old ladies, birdwatching can be a hardy and rugged activity. The typical participant is male, white, married, above av-

[3] Shaw, William A. Meanings of wildlife for Americans: contemporary attitudes and social trends. p. 151-155. *In* Transactions, 39th North American Wildlife and Natural Resources Conf., Wildlife Management Institute. 1974.

Hendee, John C. A people-contact framework for nongame wildlife management. Post-doctoral fellowship paper, College of Forest Resources, University of Washington, Seattle, WA., 122 p. 1974. (Unpublished.)

Courtesy Bureau of Sport Fisheries and Wildlife

Birdwatching is a form of outdoor recreation that appeals to millions of people.

erage in education and income, and is either retired or a young professional.[4]

Birdwatchers vary in skill and intensity of interest from casual amateurs to dedicated professionals. Many people are content simply to learn to recognize the species that use their window feeders. Others own field guides and binoculars, take bird walks, and keep a list of the birds they have identified. Still others own expensive photographic equipment, travel for the express purpose of sighting new or rare species, and are experts on bird ecology and biology.

The recent sighting of a Ross's gull near Boston illustrates the extreme dedication of many birdwatchers and the degree to which they will spend time and money to pursue their hobby. Up to 1,000 birdwatchers per day flocked to Newburyport, Massachusetts, to see this extremely rare bird; some of them drove or flew from as far away as Florida and California.[5] Aside from birdwatchers, very little is known about nonconsumptive users, but it appears they are a cross section of the general population. The chance to see a variety of wildlife is undoubtedly a major reason why visitors travel from all over the Nation to our National Parks and National Forests.

Recent Trends in Nonconsumptive Uses

As people become more interested in nonconsumptive uses, it can be expected that an increasing percentage of outdoor recreationists will want to see and understand wildlife. The scattered available data show, for example, that the number of wildlife photographers grew to more than 4.5 million by 1970 and there were nearly 7 million birdwatchers. A survey made in 1971 indicated that most visitors to National Forests in the Southeastern United States enjoyed seeing wildlife and were willing to pay a high price to do so.[6]

The direct expenditures attributable to the enjoyment of nongame birds in 1974 in the United States totaled about $500 million. For the sake of perspective, this was probably one-sixth as much as spent by all hunters but 1.7 times the amount spent by waterfowl hunters, exclusive of indirect expenditures for transportation, lodging, and food.[7]

Not only are expenditures for nongame bird enjoyment impressively high, but they have been increasing rapidly in the past several years. For example, gift bird book sales rose from $1.5 million in 1970 to $4 million in 1974. Dues paid to the National Audubon Society doubled in 5 years, increasing from $1.6 million in 1970 to $3.1 million in 1974. A more general increase in the nonconsumptive appreciation of wildlife is suggested by growth in subscriptions to *National Wildlife* magazine, which climbed from 60,000 in 1963 to 350,000 by 1975. Similarly, *Ranger Rick*, a periodical of the National Wildlife Federation, now goes to 500,000 children; its second issue in January 1967 went to 35,000.[8] It seems reasonable to expect that many of the children who read this magazine will grow up with a great awareness and appreciation of wildlife.

One of the most obvious "nonconsumptive" uses of wildlife and fish is their transformation into household pets. In 1969, for example, about 13,000 firms and individuals imported the following array of wildlife:[9]

Type of wildlife	*Number imported (thousands)*
Mammals	120
Wild birds	570
Fish	73,690
Mollusks, crustaceans	1,940
Amphibians	340
Reptiles	1,390

Most of these 78 million creatures went to the commercial pet trade.

Another indication of the popularity of simply observing animals is the 100 million annual visits paid to zoos in 1974. This is about one-fourth the number of visits for all purposes made to all areas in the National Park System (including National Parks, Monuments, Battlefields, etc.) as shown in table 32.

While attempts have been made to inventory wildlife photographers and birdwatchers, little effort has been made to measure the numbers of coyote listeners, toad or lizard holders, or others who have their own nonconsumptive interest in wildlife. These groups are not mutually exclusive. Even the most avid birdwatcher is likely to notice deer in a meadow. Indeed, it is probably the entire esthetic complex that helps focus interest upon the major source of enjoyment.

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[4] Horvath, Joseph C. Economic survey of wildlife recreation; executive summary. Environmental Res. Group, Georgia State Univ., Atlanta, GA., 68 p. 1974.

[5] The Boston Globe, page 1. March 9, 1975. (The fact that a species is rare often seems to increase its value to people. This value has been politically expressed in the Endangered Species Act and in laws designed to protect species—such as the desert tortoise and caiman alligator—from collectors.)

[6] Horvath, op. cit.

[7] Payne, Brian R., and Richard M. DeGraaf. Economic value associated with human enjoyment of nongame birds. Proceedings, Symposium on Management of Forest and Range Habitats for Nongame Birds, U.S. Department of Agriculture Forest Service Gen. Tech. Rpt. WO-1, p. 6-10. Washington, D.C. 1975.

[8] Davey, Stuart P. The role of wildlife in an urban environment. Proceedings, 32nd North American Wildlife and Natural Resources Conf., Wildlife Management Institute, p. 50-60. 1967.

[9] U.S. Department of the Interior, Fish and Wildlife Service. Importations of fish and wildlife, 1969. Division of Management and Enforcement, Pub. WL–491, 4 p. 1970.

Table 32. *Visits to city zoos, National Park System, and National Forests, 1968 and 1974*

(*Million visits*)

Facility	1968	1974
Zoos	94	100
National Park System	151	217
National Forests	157	193

Sources: Zoos—American Association Zoological Parks and Aquariums. Zoos and aquariums in the Americas. Wheeling, West Virginia, 1968 (137 p.) and 1974 (222 p.).

National Park System—U.S. Department of the Interior, Bureau of Outdoor Recreation, selected outdoor recreation statistics. Washington, D.C. 1971, and U.S. Travel Data Center, Public use of the National Parks, Washington, D.C. 1974.

National Forests—U.S. Department of Agriculture, Forest Service, RIM Inventory, unpublished. Chief's Office, Washington, D.C. 1974, and selected outdoor recreation statistics 1974, op. cit.

Courtesy Bureau of Sport Fisheries and Wildlife

People enjoy wildlife in many ways. To some, the howl of a coyote is a thrilling sound—the call of the wild.

Projected Demands for Nonconsumptive Activities

Usually wildlife is but one enriching component of a recreational experience that has a different focus. Blue jays make backyard picnics more fun and it may well be that salmon seen climbing a fish ladder are remembered long after the generators of a hydroelectric dam are forgotten.[10] Hunting is generally enriched by the presence of species other than the game that is sought. Consequently, no nationwide data are available that quantify how much nonconsumptive use of wildlife occurs.

There is information, however, on the number of people that participate in some wildland activities dependent in whole or in part upon the chance to be near wildlife.[11] Projections, based on these participation rates and the assumed increases in population and income presented in Chapter 1, indicate that nonconsumptive use is likely to rise rather rapidly in the decades ahead.[12] The medium level projections show that the number of photographers is likely to double in the next 45 years and the popularity of nature walks, birdwatching, and sight seeing increase by more than 50 percent (table 17, fig. 16). The alternative assumptions on population and income have important effects on projected demands. Projected demands under the high level assumption, for example, are about 15 percent above the medium levels.

A regional projection has also been made of the desires for nonconsumptive enjoyment of wildlife that will probably not be met.[13] In parts of eight States bordering on the Great Lakes, that deficit is expected to increase to more than 16 million desired opportunities in the next 50 years, given current

[10] Lime, David W., and Charles T. Cushwa. Wildlife esthetics and auto campers in the Superior National Forest. U.S. Department of Agriculture Forest Service, North Central For. Exp. Sta., St. Paul, MN., Res. Pap. NC-32, 8 p. 1969.

[11] Participation rates developed in U.S. Department of the Interior, Bureau of Outdoor Recreation. Outdoor Recreation in America: Appendix A, An Economic Analysis. 239 p. Dec. 1973.

[12] For details on the projections see U.S. Department of Agriculture, Forest Service. Methodology used for 1975 outdoor recreation projections. Washington, D.C. June 1975. (Unpublished.)

[13] Great Lakes Basin Commission. Great Lakes Basin framework study: Appendix 17—wildlife. 140 p. Ann Arbor, Michigan. 1975.

Mid-level projections of demand for outdoor recreation activities at least partly dependent upon the nonconsumptive uses of wildlife

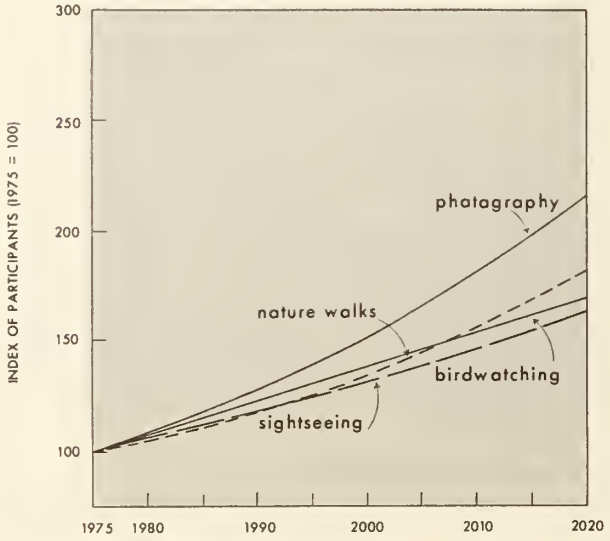

Figure 16

trends in losses of wildlife habitat and perceptions of wildlife.[14]

Supply of Nonconsumed Wildlife Populations

In later sections, trends in populations of major groups of hunted wildlife are presented. But for the great majority of nongame species, the question of whether a particular species has been increasing or decreasing has been a matter of conjecture based on little quantitative evidence. Since the mid-1960's though, the North American Breeding Bird Survey has provided quantitative data on variations in population of most bird species.

Populations of most nongame birds have been relatively stable for the past decade, especially over broad geographic areas. The principal exceptions to this generality are the following:[15]

Species	*Population trend since mid-1960's*
Cattle egret	Increasing 12 percent annually east of Mississippi
Robin	Increasing 6 percent annually in central States
Starling	Increasing 5 percent annually in North America
Eastern bluebird	Decreased from 1966 to 1969, increasing since that time
Barn swallow, tufted titmouse	Breeding ranges expanding in East
Upland sandpiper, Mississippi kite	Apparently increasing since 1969
Red-eye vireo, ovenbird, American redstart	Significant decreases in early 1960's, 10 percent annual increase in Canadian breeding grounds since that time
Red-winged blackbird, common grackle, brown-headed cowbird	Substantial increases
Yellow-shafted flicker, red-headed woodpecker	Decreasing 3 percent annually
Yellow warbler	Decreasing 5 percent annually in western States
Cedar waxwing	Decreasing 7 percent annually in North America

The largest population increases have been recorded for introduced species including the cattle egret and the starling. The population explosion of the starling in the western States is thought to pose a threat to certain agricultural interests and probably, through competition for nesting space, has been responsible for the decline of the yellow-shafted flicker and the red-headed woodpecker. Similarly, the native brown-headed cowbird, in combination with extensive changes in natural habitats, has had a disastrous impact on the now endangered Kirtland's warbler[16] and a lesser impact on the yellow warbler.

Although these birds and many other wildlife species are not hunted, intensive demands for nonconsumptive uses can destroy the enjoyment of wildlife or even endanger wildlife populations. Too many birdwatchers destroy the likelihood of spotting an elusive warbler. Too much feeding of park bears leads to changing them from wild to apparently tame—but always dangerous—zoo animals. The emotional experience derived from wilderness wildlife is lessened by crowds of admirers, and those wildlife species that are intolerant of man's activities can be adversely affected.

Endangered and Threatened Wildlife Species

The extreme instances where wildlife "availability" is of serious concern are represented by endangered species, those that are currently in danger of extinction, and threatened species, those that are likely to become endangered in the foreseeable future.

Although the extinction of living species has occurred throughout history, in modern times the rate of extinction has greatly accelerated, and there is

[14] Hendee, J. C., and R. J. Burdge. The substitutability concept: implications for recreation research and management. J. Leisure Res. 6: 157-162. 1974.

Krieger, M. H. What's wrong with plastic trees? Science 179: 446-455. 1973.

[15] Robbins, Chandler S., and Anthony J. Erskin. Population trends in nongame birds in North America. p. 288-293 *in* Transactions, 40th North American Wildlife and Natural Resources Conf., Wildlife Management Institute, 1975.

[16] Huron National Forest. A bird of fire: Kirtland's warbler. U.S. Department of Agriculture, Forest Service, Washington, D.C. 8 p. 1975.

Courtesy Bureau of Sport Fisheries and Wildlife

The cattle egret, an insect eater, is the first bird in recent times known to have reached the United States from another continent on its own. The population of this bird, and the starling, another introduced species, has been increasing rapidly.

F-505376

Some endangered species, such as the California condor, require relatively large areas of undisturbed habitat for survival.

general agreement that human activities, primarily those associated with land development, are responsible for this increase.[17] In the United States, not fewer than 40 species of birds and mammals have disappeared since 1820. The Fish and Wildlife Service classified as endangered or threatened 143 species of wildlife in the United States, the Virgin Islands, Puerto Rico and the trust territories (as of December 1975). Included were 31 mammals, 66 birds, 8 reptiles, 4 amphibians and 34 fish.

Most of these species are geographic isolates,[18] the most obvious being those species endemic to oceanic islands. In Hawaii, 25 species or subspecies (almost 40 percent) of native birds are known or believed to be extinct, and an additional 25 species are considered rare or endangered.[19] Of the two native Hawaiian mammals—the Hawaiian hoary bat and the Hawaiian monk seal—the former has been proposed as endangered and the latter is becoming rare and may become endangered. Puerto Rico has recently lost the Mauge's Parakeet and the Culebra Puerto Rican Parrot, and seven other species and subspecies are considered threatened.

In the Southern, Southwestern, and Western States, many species and subspecies of endangered vertebrates are also restricted to isolated habitats (more than three-quarters are aquatic habitats). Many of these geographically isolated species evolved in restricted habitats and were never very abundant. For others, however, their "islands" are remnants of vegetative associations once much greater in expanse but now reduced through habitat changes. In either case, the restricted range, habitat, and populations of these isolated species make them highly vulnerable to extinction from continued habitat changes or destruction.

The other species are wide-ranging. Habitat alteration has had a profound impact on these species also, often by restricting an animal's range and iso-

[17] Fawcett, Charles W. Vanishing wildlife and federal protective efforts. Ecology Law Quarterly 1(3): 520-560. 1971.

[18] U.S. Department of the Interior, Fish and Wildlife Service. Final environmental statement for the proposed Endangered Species Conservation Act of 1973, H.R. 4758. Washington, D.C. 1973.

[19] Berger, Andrew J. Hawaiian birdlife. University Press, Univ. of Hawaii, Honolulu. 270 p. 1972.

lating populations. In other cases, where the expanse of a particular vegetative association has not diminished significantly, land management practices have tended to decrease ecological diversity, removing key habitat features essential to the survival of some species.

Management Opportunities

The Endangered Species Act of 1973 declared:

> Sec. 2.(c) "Policy.—It is further declared to be the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purpose of the Act."
>
> Sec. 3. "For the purposes of this Act . . .(2) The terms "conserve", "conserving", and "conservation" mean to use all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary. . . ."

As understanding of species requirements increases, efforts to ensure that those requirements are met also will increase. For some endangered and threatened species, notably those most restricted and isolated, this will consist of preserving all available habitat and protecting it from further encroachment. In addition, it may be possible to extend some species' restricted or depleted ranges by transplanting them to presently unoccupied or newly developed habitats.[20] The conservation of other species requires that their needs be considered along with the management of associated resources. Perhaps most important is to recognize potential dangers and take corrective action before more wildlife populations are threatened.

In contrast, meeting the demand for opportunities to enjoy more common animals generally amounts to providing nondestructive access to wildlife and publicizing the opportunities for observation. Especially near campgrounds and in the fringes of urbanized areas, it is also possible to create mini-environments that will attract wildlife, particularly birds and small mammals.[21]

Nonconsumptive uses of wildlife can generally be managed unobtrusively. For instance, if birdwatchers begin to utilize certain trails in excessive numbers, land managers can create additional trails in suitable habitats or publicize other areas that are equally good for birdwatching but less known to the public.[22] Encouraging camping early in the summer to observe wildlife might both provide new opportunities and decrease camping pressures during peak periods.

Plant communities go through a sucession of stages from the most primitive plants to a mature community. For example, forests generally progress from grass and forbs, to shrubs, saplings, small trees, and finally to a mature forest. Each stage is particularly suited to a specific complex of animal life. As one stage of development merges into the next, the animal community associated with the first also gives way to a new community.[23] Newly available research results are providing a basis for the manipulation of these stages so that wildlife numbers and variety can be preserved or increased in wildlands.[24]

The number of bird species is lowest in the deserts and high plains of the Southwest and increases to the East and North, reaching a peak in the northern hardwood forests.[25] The opportunity exists through appropriate forest management practices to showcase part of this diversity, especially in areas near major population centers in the Northeastern States. A number of these management practices—such as creating numerous small forest openings and preserving large dead trees to provide nests, dens, feeding areas, cover, and perches—are now being applied for this purpose.[26]

The following could be of considerable benefit in managing nonconsumptive uses of wildlife:

Management activities	*Example*
Restrictive—limiting human activity	Preventing intrusions in critical habitat; limiting hunting for selected species.
Coordinating—coordination with other resource uses	Favoring wildlife diversity by perpetuating a variety of shrub and tree species; creating numerous small forest openings
Positive—expenditures explicitly for nonconsumptive use of wildlife	Establishing local nature exhibits; constructing self-guiding nature trails; publicizing opportunities for observation.

[20] For an example of priority system for allocating scarce management dollars among species, see: Sparrowe, Rollin D., and Howard M. Wight. Setting priorities for the endangered species program. p. 142-156 *in* Transactions, 40th North American Wildlife and National Resources Conf., Wildlife Management Institute, 1975.

[21] Thomas, Jack Ward, Robert O. Brush, and Richard M. DeGraaf. Invite wildlife to your backyard. National Wildlife 11(3): 5-16. 1974.

[22] Gill, J. D., R. M. DeGraaf, and J. W. Thomas. Forest habitat management for nongame birds in central Appalachia. U.S. Department of Agriculture Forest Service, Northeastern Forest Exp. Sta., Upper Darby, Pa. Res. Note NE-192. 6 p. 1974.

[23] Thomas, J. W., G. L. Crouch, R. S. Bumstead, and L. D. Bryant. Silvicultural options and habitat values in coniferous forests. Proceedings, Symposium on Management of Forest and Range Habitats for Nongame Birds, U.S. Department of Agriculture Forest Service. Gen. Tech. Rpt. WO-1 p. 272-287. Washington, D.C. 1975.

[24] Hooper, R. G., Hewlette S. Crawford, and Richard F. Harlow. Bird density and diversity as related to vegetation in forest recreational areas. J. For. 71(12): 766-769, 1973.

[25] Robbins and Erskine, op. cit.

[26] Siderts, Karl. Forest diversity: an approach to forest wildlife management. For. Chron. 51(3): 99-103. 1975.

Big Game and Small Game Hunting

For purposes of this discussion, big game includes those large animals (including turkeys) that may legally be hunted in the United States. Small game includes the other hunted mammals and upland birds.

Courtesy Bureau of Sport Fisheries and Wildlife

In the fall upland bird hunting is popular with millions of Americans—partly because of the opportunity to walk in fields and forests during a beautiful season of the year.

Characteristics of Hunters

In 1970, there were about 14.3 million hunters in the United States; 7.8 million hunted big game and 11.7 million hunted small game. These totals are broken down on a broad regional basis in table 33. The greatest numbers of hunters were found in the most populated parts of the country, but the rates of participation in big game hunting were highest in the Western (Rocky Mountain and Pacific Coastal) States; participation rates in small game hunting were highest in the Plains States between the Mississippi River and the Rocky Mountains.

Hunters come from all income groups. While a number of small-scale, intensive studies suggest that no income class is disproportionately represented,[27] the 1970 national survey found that participation rates were highest among families with annual incomes of between $5,000 and $10,000 per year.[28]

Annual family income	*Hunter families as a percentage of all families*	
	Big game (percent)	*Small game (percent)*
$0—$5,000	3.0	5.0
$5,000—$10,000	6.5	9.6
$10,000—$15,000	5.6	8.2
$15,000—$25,000	3.9	6.6
Over $25,000	2.7	5.0

More than a third of both big game and small game hunters were between 25 and 45 years of age. A somewhat smaller proportion were either younger or older.

The dollars spent by hunters—nearly $2 billion in 1970—are critical to the economies of many rural

[27] Hendee, John C., and Dale R. Potter. Hunters and hunting: management implications of research. *In* Proceedings, Recreation Applications Workshop, U.S. Department of Agriculture Forest Service, Asheville, NC. 1975. (In process.)

[28] Descriptive information concerning wildlife and fish users and their expenditures throughout this report, unless noted otherwise, are drawn from the 1970 national survey: U.S. Department of the Interior, Fish and Wildlife Service. National survey of fishing and hunting. 108 p. Washington, D.C. 1972. See Appendix C of that report for reasons why estimates, especially of numbers of participants, are thought to be conservative.

Table 33. *Number of big game and small game hunters in the United States, by region, 1970*

Region	Big game hunters			Small game hunters		
	Number	Regional distribution	Relation to region population	Number	Regional distribution	Relation to region population
	Million	*Percent*	*Percent*	*Million*	*Percent*	*Percent*
Northeastern	3.2	42	4.8	4.2	36	6.1
Southeastern	1.3	16	3.8	2.8	24	8.6
Plains	1.6	21	5.9	3.1	26	11.2
Western	1.7	21	6.4	1.6	14	6.1
Total	7.8	100	5.0	11.7	100	7.5

Source: U.S. Department of the Interior, Fish and Wildlife Service. National survey of fishing and hunting. 108 p. 1972.

communities. Big game hunters spent the most per day in the field:

Activity	*Total spending (million dollars)*	*Spending per person (dollars)*	*Spending per day (dollars*	*Days per person (number)*
Big game hunting	953	122	17	7
Small game hunting	946	81	8	11

These expenditures are also directly important to wildlife since the major share of the costs of maintaining populations of wildlife and fish is financed by the license fees charged hunters and fishermen and by excise taxes on firearms, ammunition, and fishing tackle. These sources provided 82 percent of the funds for State fish and game agencies in 1973.[29] Such monies have both paid for administrative controls and contributed substantially to wildlife research and habitat improvements, including those which have benefited nongame species. Additional support is provided directly by general tax revenues through federal programs and through donations, and indirectly through private land owners who charge for or provide free access to their lands.

Recent Trends in Hunting

The number of hunters has been growing, with a 20 percent increase in small game hunters and an 80 percent increase in big game hunters between 1955 and 1970. In 1970, more than two-thirds of all hunters came from rural backgrounds and environments that introduced them to hunting at an early age. Such early exposure is an important factor in encouraging hunting.[30] As urbanization of the nation increases, this may well decline.

Big game hunting.—A variety of big game species is available for hunting on forest and range lands. Table 34 indicates where the principal species are found, the approximate number harvested in 1970, and trends in harvest over the last three decades. Only antelope, white-tailed deer, javelina, and turkeys are harvested primarily on non-Federal lands, as shown in table 35.

Small game hunting—Small game species include upland game birds and small mammals such as squirrels, rabbits, and the furbearers. In the mid-1960's, annual harvests of the most sought species averaged as follows:[31]

Species	*Number harvested (million)*
Pheasants	12.5
Grouse	3.5
Partridge	1.0
Quail	40.0
Doves	37.5
Squirrels	40.0
Rabbits, hares	34.0

Two notable differences exist between small game and big game species. The first is simply the number of animals: there are many more small animals. The second is their location. No more than 10 percent of any of the above harvests were from Federal lands except for grouse (20 percent) and partridge (44 percent).

Data from 1970 indicate the following breakdown of small game hunters by the species they hunt:

Species	*Number of hunters (million)*
Upland game birds	3.1
Doves	2.5
Woodcocks	.7
Rails and snipes	.2
Varmints	1.3

[29] Wildlife Management Institute. National survey of state fish and wildlife funding. 40 p. Washington, D.C. 1975.

Courtesy Bureau of Sport Fisheries and Wildlife

Mule deer are important big game animals in the forested mountains and desert foothills east of the Cascades.

[30] Bevins, M. I., R. S. Bond, T. J. Corcoran, K. B. McIntosh, and R. J. McNeil. Characteristics of hunters and fishermen in six Northeastern States. Vermont Agr. Exp. Sta. Bull. 656, 76 p. Univ. of Vermont, Burlington, VT. 1968.

[31] Public Land Law Review Commission. Fish and wildlife resources on the public lands. Vol. 2, p. 214-326. Washington, D.C. 1967.

Table 34. *Trends in harvests of principal big game species in the United States, by species.*

Species	Principal range	Index of harvests (1970=100)			1970
		1950's	1960's	1970	
					Number
Deer, white-tailed	Everywhere except western mountains and prairies	50	110	100	1,300,000
Deer, mule	Forested mountains, western desert foothills to Cascade Mountains	110	105	100	570,000
Deer, black-tailed	Forest from Cascade Mountains west	200	210	100	66,000
Elk	Drier portions of Rocky Mountains (Rocky Mountain elk) and Cascade and Coastal Mountains and Alaska (Roosevelt elk)	70	90	100	92,000
Pronghorn antelope	Open grasslands from Texas to Canada	70	90	100	68,000
Javelina	Southwestern desert shrub and adjacent habitats	80	75	100	8,400
Bighorn sheep	High mountain ranges in Alaska (Doll sheep), Northern Rockies (Rocky Mountain sheep), and the Southwest (desert sheep)	 50	100 100	100 100	[1]1,300 [2]400
Mountain goat	Above timberline in Southern Alaska, Washington, Idaho and Montana and Colorado	 40	90 110	100 100	[1]700 [2]900
Bear, grizzly and brown	Forests of Wyoming, Idaho, Montana and Alaska (grizzly bear); coastal areas of Alaska forests (brown bear)	.....	110	100	[1]650
Bear, black	Isolated blocks of coniferous and deciduous forest land	105	135	100	17,000
Moose	Riparian and wetland habitats producing hardwoods in Alaska, Idaho, Wyoming, Montana, Utah, Minnesota, and Maine	 40	90 80	100 100	[1]9,000 [2]1,800
Turkey	Southeastern and Southern deciduous forest (eastern); Texas and Oklahoma (Rio Grande); western mountains of Colorado, Arizona, and New Mexico (Merriam's)	40	70	100	[3]138,000

[1] Harvest in Alaska.

[2] Harvest in contiguous United States.

[3] About three-quarters were eastern turkeys.

Source: Derived from U.S. Department of the Interior, Fish and Wildlife Service. *Big game inventory*. Washington, D.C. (annual reports) 1950–1970.

Other species that are sometimes considered as small game are collectively called varmints. Included are a variety of species such as coyotes, porcupines, rats, prairie dogs, crows, sparrows, and starlings.

Trapping.—Those mammals collectively called furbearers have been harvested primarily by trapping, with the number of trappers varying with the market price of furs. Fur production flourished in the United States until the late 1940's when the low demand for fur apparel and low earnings caused a sharp reduction in the number of trappers.[32] Between 1950 and 1973, six States (Colorado, Iowa, Louisiana, Michigan, Minnesota, and Oregon) reported that trapping license sales varied from 28,500 to 46,000 with the low point in the late 1960's. Conservative estimates of the total harvest of the principal furbearers are shown in table 36.

[32] U.S. Department of Commerce. Summary of information on furs—raw furs. 17 p. Washington D.C. 1965.

Table 35. *Percentage distribution of big game species harvested in the United States, by major ownership and species, 1970*

Species	Major Federal lands		All other lands
	Forest Service	Bureau of Land Management	
	Percent	*Percent*	*Percent*
Antelope	9	40	51
Bear, black	48	4	48
Bear, brown and grizzly[1]	28	38	34
Caribou[1]	0	100	0
Deer, white-tailed	9	(2)	91
Deer, mule	50	27	23
Deer, black-tailed	36	33	31
Elk	79	6	15
Goat, mountain[1,3]	89	16	0
Javelina	36	8	56
Moose[1]	26	35	39
Sheep, bighorn[1,3]	32	79	0
Turkey, Merriam's	65	2	33
Turkey, Rio Grande	0	0	100

[1] Primarily harvested in Alaska.

[2] Trace.

[3] Agency reports conflict with State data.

Source: Forest Service data—U.S. Department of Agriculture, Forest Service, 1971 Annual wildlife report; BLM—U.S. Department of the Interior, Bureau of Land Management, 1971 Annual wildlife report; all other lands—national control totals (reported by States), U.S. Department of the Interior, Fish and Wildlife Service, Big game inventory for 1970.

Courtesy Bureau of Sport Fisheries and Wildlife

Bobwhite quail—the Nation's most popular game bird—some 40 million are harvested each year.

Projections of Demand for Hunting

As indicated above, the number of hunters—both small and big game—has been growing rapidly. Projections based on past participation rates and likely future population trends show continued growth[33] (table 37, figs. 17 and 18). For example, the medium-level projections show that, given hunting opportunities in the future that are of adequate quality and with acceptable costs for travel and other items, the number of big game hunters is likely to increase by two-thirds and the number of small game hunters by one-third over the planning period.

These projections reflect expectations of the following kinds of shifts in the age of hunters:

Age group	*Percent of hunters*	
	1970	*2020*
12–15	8	4 to 6
16–17	5	3 to 4
18–24	18	11 to 14
25–34	28	about the same
35–44	17	24 to 26
45–64	20	about the same
65+	4	about the same

As the population ages, younger hunters will become relatively less abundant and the 40's group will increase substantially. Although there is little avail-

[33] For details of the derivation of the projections of demands for wildlife and fish throughout this chapter, see: McKeever, David B. Long-term projections of demand for forest related outdoor recreation in the United States. Pennsylvania State Univ. University Park, PA. Master's thesis. 1975. (Unpublished.)

Table 36. *Harvest of principal furbearing species in 17 selected States, by species, 1955–70*

(Thousands)

Year	Species						
	Mink	Muskrat	Nutria	Opossum	Raccoon	Beaver	Fox
1955	310	3,810	370	170	770	90	110
1960	280	4,180	690	190	1,040	80	110
1965	230	3,210	1,570	130	1,020	80	140
1970	170	4,390	1,610	140	1,380	70	160

Source: Data provided by State game agencies of Arkansas, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Missouri, Montana, Nebraska, North Carolina, North Dakota, Ohio, Pennsylvania, Tennessee, and Wisconsin.

Table 37. *Projected indexes of demand for hunting and fishing in the United States, by major activity, 1975–2020*

(1975=100)

Activity		Year					
		1975	1980	1990	2000	2010	2020
Big game hunting	High	100	111	128	146	169	194
	Medium	100	111	127	139	152	164
	Low	100	111	126	134	141	145
Small game hunting	High	100	106	114	129	145	163
	Medium	100	106	113	121	129	136
	Low	100	106	112	115	117	118
Waterfowl hunting	High	100	106	114	129	145	163
	Medium	100	106	113	121	129	136
	Low	100	106	112	115	117	118
Fresh water fishing	High	100	111	135	167	203	247
	Medium	100	111	133	156	180	205
	Low	100	111	131	148	164	178
Saltwater fishing	High	100	119	158	207	267	338
	Medium	100	119	156	196	238	283
	Low	100	119	155	187	218	248

Source: McKeever, David B. Long-term projections of demand for forest related outdoor recreation in the United States. Penn. State Univ., Master's thesis. 1975. (Unpublished.)

Projections of demand for big game hunting

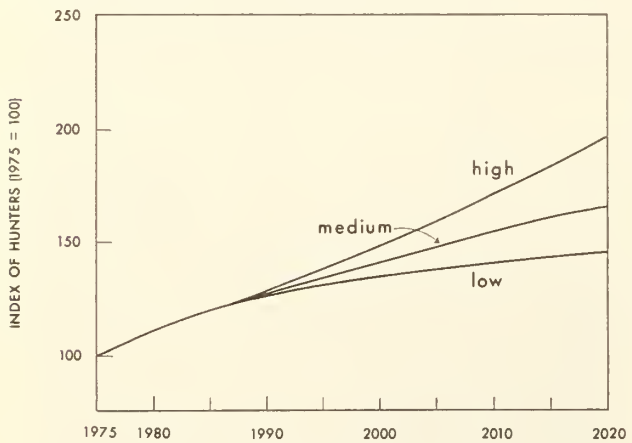

Figure 17

Projections of demand for small game hunting

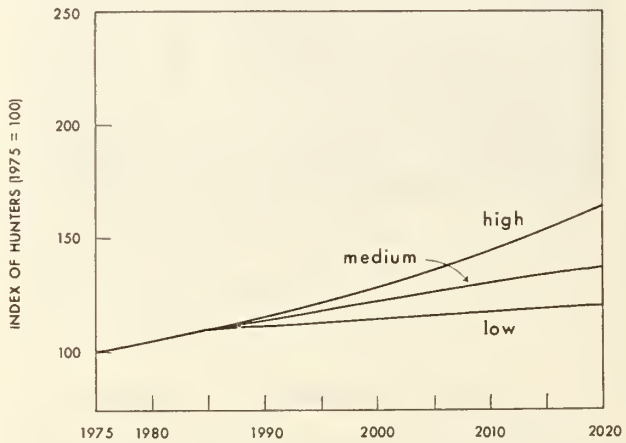

Figure 18

able empirical evidence to support conclusions regarding how types of hunting preference change with age, it appears reasonable to expect that hunters will want less rugged hunting conditions.[34]

Expected changes in the distribution of our nation's population also suggest that there will be a slight relative increase in hunting—a few percentage points—in the Southern States at the expense of the Plains States.

The alternative projections on population growth and income have important effects on projected demands and particularly in the decades beyond 2000. The growth is substantial, however, under all assumptions.

There are a number of other factors, not explicitly recognized in the projections, that could influence the future of hunting. Most dramatically, a sentiment opposing hunting on moral grounds has surfaced at state and national levels. For example, it was reported that about 40 percent of New Jersey's residents opposed deer hunting in the early 1970's[35] and a concerted effort was recently made to stop all waterfowl hunting[36].

Several other influences that could become quite significant include:

—Cultural changes in viewing hunting that are associated with increasing urbanization

—A decrease in accessibility to private lands or in hunter success ratios

—Restrictions on travel caused by energy shortages.[37]

Supplies of Game Animals and Management Opportunities

While the demands for all kinds of hunting opportunities have been rising rapidly in the past few decades, the hunting land base per capita has diminished, and this trend will most likely continue. For example, 75 million acres across eight States bordering the Great Lakes currently contains about 9 acres of wildlife habitat per person; expected population increases and associated land developments will reduce the acreage per person by one-third in the next 50 years. The same study found that while about 90 percent of the forest land base can be hunted, only two-thirds of the pastureland and a quarter of cropland provide opportunities for hunting.[38]

Small game hunting has intensified on public lands—which were underutilized until recently—and, more importantly, on private lands. New pressures for big game hunting have been absorbed in the past by the ability of regulating agencies to increase harvest rates within safe biological limits and to expand and publicize the ranges of some species, particularly deer and turkeys. Increased harvests and hunter participation rates provide evidence that these techniques have been successful during the past several decades.

There are indications that limits to these increases are now being approached. Success rates have recently declined, and apparently are concentrated to the advantage of relatively few hunters;[39] the result may be a less-than-satisfactory experience for some participants.[40] Crowding and competition for space and game have led to a variety of new strategies for regulating and rationing hunting.

Big game populations.—The managers of public forest and range lands are responsible for ensuring that there are adequate habitats for the majority of big game animals in the United States. To meet present and future demands for big game hunting, a large share of the effort to improve habitat must occur on public lands. There is great potential, as the public Land Law Review Commission noted:

> Public lands fall far short of their potential for producing wildlife (both game and fish) and making it available for public use and enjoyment. The production of wildlife on most Federal land is a byproduct of its use for other purposes. Furthermore, the availabil-

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[34] For a general discussion of the relationships between age and outdoor recreation activities, see: Marcin, Thomas C., and David W. Lime. Our changing population structure: what will it mean for future outdoor recreation use? Proceedings, National Symposium on Economics of Outdoor Recreation, New Orleans, LA. U.S. Department of Agriculture Forest Service, Washington, D.C. 1975. (In press.)

[35] Applegate, James E. Attitudes toward deer hunting in New Jersey: A second look. Wildlife Society Bull. 3(1): 3–6. 1975.

[36] Wildlife Management Institute. Attempt to stop waterfowl hunting stalled. News Release, November 1, 1974. p. 2. Washington, D.C.

[37] Zuzanek, Jiri. Society of leisure or the harried leisure class? Leisure trends in industrial societies. J. Leisure Res. 6(4): 293–304. 1974.

[38] Great Lakes Basin Commission. Great Lakes Basin framework study: Appendix 17—Wildlife. 140 p. Ann Arbor, Michigan. 1975.

[39] For a case study in small game hunting, see Potter, Dale R., John C. Hendee, and Lee E. Evison. Hunters at regulated plant-and-shoot pheasant areas in western Washington. U.S. Department of Agriculture Forest Service, Pacific Northwest Forest and Range Exp. Sta., Portland, Oregon. Research Paper PNW–160, 30 p. 1973.

[40] Potter, Dale R., John C. Hendee, and Roger N. Clark. Hunting satisfaction: game, guns, or nature? p. 220–229 *in* Transactions, 38th North American Wildlife and Natural Resources Conf., Wildlife Management Institute. 1973.

Stankey, George H., Robert C. Lucas, and Robert H. Ream. Relationships between hunting success and satisfaction. p. 235–242 *in* Transactions, 38th North American Wildlife and Natural Resources Conf. Wildlife Management Institute. 1973.

Hendee, John C. A multiple-satisfaction approach to game management. Wildlife Society Bull. 2(3): 104–113. 1974.

For a more general discussion of the effects of crowding in outdoor recreation, see Wagar, J. Alan. The carrying capacity of wild lands for recreation. Forest Science Monograph 7, 24 p. 1964.

ity of this fish and wildlife for use by the public occurs largely by chance. . .[41]

There is some empirical evidence to suggest that present demands for big game hunting opportunities are not being met. The number of visits to the National Forests by big game hunters since 1950 and success rates, as measured by the combined harvests of elk and deer, are shown in figure 19. As improved highways and forest road networks and increasing disposable income permitted a rapid increase in the number of big game hunters, their success rate fell. When the success rate dropped to about 6 percent, the number of visits by hunters stabilized. Perhaps the capacity of the National Forests to provide satisfactory big game hunting experiences, under the prevailing system of wildlife habitat management, was reached in the mid-1960's. To the extent this is true, further increases in big game hunting on these lands is unlikely in the absence of more intensive habitat management programs and the application of more sophisticated techniques of hunter regulation to ensure satisfactory hunting experiences.

The most critical factors bearing on the supplies of the principal big game species are briefly summarized in the tabulation below.

Numbers of big game hunter visits and harvest rates of elk and deer combined on National Forests, 1950 - 1973

Figure 19

[41] Public Land Law Review Commission, op. cit.

Big game species	*Needs and current or potential problems*	*Other comment*
Deer, white-tailed	Flourishes in second-growth, discontinuous forests managed under short rotations; replacement of hardwoods with conifers is damaging.	Most widespread big game species
Deer, mule	Reasons for recently declining harvests uncertain. Some livestock grazing conflicts.	—
Deer, black-tailed	Timber harvesting generally beneficial in old-growth forests. Attendant road development has increased accessibility for hunters.	Can withstand additional harvest. May partially replace mule deer for northwest hunters.
Elk	Most serious problems are interruptions of migratory routes and human infringements on winter ranges. Widespread timbering activities on summer range may be detrimental because of disturbances, increased human contacts, and loss of cover.	Populations are generally healthy. Careful coordination of timber sale activities with elk habitat requirements is necessary to maintain present populations.
Pronghorn antelope	May compete with sheep and, occasionally, cattle for forage on less productive or overgrazed rangelands. Fences impede free movement.	Populations have been increased through harvest controls, transplanting, and range development.
Javelina	Range is largely defined by primary food, pad cactus. Locally, prickly pear eradication and large-scale brush control programs favoring grass production have been detrimental.	Brush encroachment on overgrazed southwestern rangelands has led to increase in suitable habitat.
Bighorn sheep	Suitable range is limited. Localized conflicts for forage with domestic sheep.	Transplanting to supplement range is promising.
Mountain goat	Suitable range is limited	Transplanting to supplement range is promising.

Big game species	*Needs and current or potential problems*	*Other comment*
Bear	Generally require large blocks of forest interspersed with grasslands. Minimizing confrontations between bears and humans is critical.	—
Moose	Require willow bottom riparian habitats for overwintering, but will destroy own food supply if not controlled. Conflicts occur with other ungulate wildlife for winter range.	Controlled fire effective in perpetuating food supply.
Turkey, eastern	Recent population increases due to maturing, 70+ year-old deciduous forest with open understories. Conversion to pine is detrimental. Short timber rotations are probably detrimental.	Probably is the major gain in huntable populations for many decades.
Turkey, Rio Grande	Below normal spring and summer rains and heavy rangeland grazing pressures by livestock markedly reduce reproductive success.	Increased harvests due to increased hunter interest. Source of income for private landowners over much of its range.
Turkey, Merriam's	Migratory from forested uplands to open ponderosa pine forests. Minimizing human contacts, including timbering and domestic livestock grazing, would be desirable.	—

Small game populations.—A major problem in meeting demands for small game hunting will continue to be access. With adequate access and the widespread application of available management techniques, some small game populations conceivably could take some hunting pressures off more limited game resources. For example, in the past 10 years an increasing proportion of waterfowl hunters have begun to hunt woodcock, especially in the Northeastern States.[42]

The great bulk of small game hunting is on privately owned lands. As ever more small game hunters visit private lands, though, it is unrealistic to expect enough owners to be willing to open their lands without reimbursement. Fee hunting programs have proven successful to the extent that landowners see them as profitable. Hunters are assured of a place to hunt in whatever degree of solitude they are willing to pay for. Shooting preserves, where game is raised and stocked for hunting, provide a means of concentrating large numbers of hunters on small land areas without endangering wild populations. At this time, though, many hunters still resist paying for the privilege to hunt.[43]

The most likely approach to ensure that wildlife habitats will be improved and that wildlife populations will be available to hunters on private lands is to provide economic incentives to the landowners. This could be done in conjunction with assistance programs designed to stimulate timber production. Some cost-sharing Federal-State cooperative programs already exist that could be expanded for this purpose, including:

—Federal aid in wildlife restoration, administered by the Fish and Wildlife Service through State directors of fish and game departments;

—Cooperative forest management, administered by the Forest Service through State foresters;

—Outdoor recreation assistance, administered by the Bureau of Recreation through State directors of recreation programs; and

—Cooperative extension programs, administered by the Federal Extension Service through State directors of extension at land grant universities.[44]

The great bulk of the Nation's forest and range land is in small, nonindustrial ownerships. The owners have widely varying land management objectives, relatively short tenures, and, for the most part, lack the knowledge and capital to practice efficient management. Consequently, technical and financial incentives are necessary to encourage these owners to adopt and follow effective management practices.[45]

Although small game occurs in many different vegetative types across the Nation, the information below, drawn from the Southeast, suggests the kinds of problems and opportunities that exist in the management of small game habitat.[46]

[42] Artmann, Joseph W. The status of American Woodcock—1975. U.S. Department of the Interior, Fish and Wildlife Service. Administrative Report. 19 p. 1975.

[43] Ryland, Errol E. Pay-as-you-go hunting. p. 44–49 *in* Wildlife and the Environment, Info. Series No. 7, Environmental Resources Center, Colorado State Univ., Fort Collins, CO. 1973.

[44] Shaw, Samuel P. Forest wildlife responsibilities—what's our problem? J. For. 68(5): 270–273. 1970.

[45] Shaw, Samuel P., and David A. Gansner, Incentives to enhance timber and wildlife management on private forest lands. p. 177–185 *in* Transactions, 40th North American Wildlife Natural Resources Conf., Wildlife Management Institute. 1975.

[46] Holbrook, Herman L. A system for wildlife habitat management on southern National Forests. Wildlife Society Bull. 2(3): 119–123. 1974.

Small game species	*Needs and problems*	*Management opportunities*
Squirrel	Dependent upon mast-bearing hardwoods for food and shelter. Conversion of hardwoods to pines, shortened rotations, reservoir construction, and drainage projects threaten habitat.	Keep substantial acreages in hardwood types on long rotations. Favor den trees.
Rabbit	Require forests in early stages of succession	Habitat can be improved through timber harvesting.
Fox	No major problems	Same.
Raccoon	Major problems are drainage of wetlands and conversion of hardwoods to pine.	Keep substantial acreages in hardwood types and wetlands.
Bobwhite quail	Dependent upon mixture of open forests, brush, grass, and cultivated lands. Problems are dense crown canopies and thick ground litter.	Habitat can be improved through prescribed burning, moderate grazing, logging and planting food crops.
Ruffed grouse	Problems are lack of variety of ground cover and of age classes of timber.	Create small open areas throughout habitat.
Mourning dove	Dependent upon intensive agricultural practices	Plant attractive foods.
Woodcock	Large scale impoundments, conversion of bottomland forests to cropland and improved pasture, and urban development are primary threats	Logging, light grazing, and prescribed burning can be harmful.

Courtesy Bureau of Sport Fisheries and Wildlife

More squirrels—some 40 million annually—are harvested than any other small game animal. Squirrels are dependent upon mast-bearing hardwoods, such as the oaks and hickories, for food and shelter.

Broad classes of activities that hold promise for correcting current problems and minimizing future problems facing big game and small game wildlife populations can be categorized as follows:

Management activities	*Examples*
Restrictive—limiting human activity.	Zone land for development to preserve big game winter ranges and other green spaces; preserve wetlands; closely regulate hunting and mechanized recreation.
Coordinating—coordination with other resource management	Utilize prescribed burning to perpetuate food species; favor timber management systems that lead to mixtures of newly regenerated areas and a variety of age classes.
Positive—expenditures explicitly for game production	Plant food species; accelerate cost-sharing and tax programs as incentives to private owners.

With a few exceptions, the options now employed by public land management agencies are coordinating activities. Coordination with commodity production activities, and especially with grazing and logging and road construction, seems to be the best way to ensure healthy wildlife populations on public lands. It is also worth noting that the Sikes Act of 1974 (P.L. 93–452) provides a mechanism to develop habitats for a variety of wildlife and fish. On private lands, incentive programs for landowners will be necessary in order to increase wildlife populations and ensure their accessibility to hunters.

Waterfowl Hunting

Of the 46 species of ducks, geese, brant, and swans native to the United States and Canada, 39 species are normally hunted. The one-fourth of these waterfowl that breed in the United States concentrate in the glaciated pothole region of the Dakotas, western Minnesota, and eastern Montana, and in Alaska. Migrating and wintering waterfowl use coastal wetlands, flooded river bottoms, water re-

AVERAGE DISTRIBUTION OF NORTH AMERICAN BREEDING AND WINTERING DUCKS

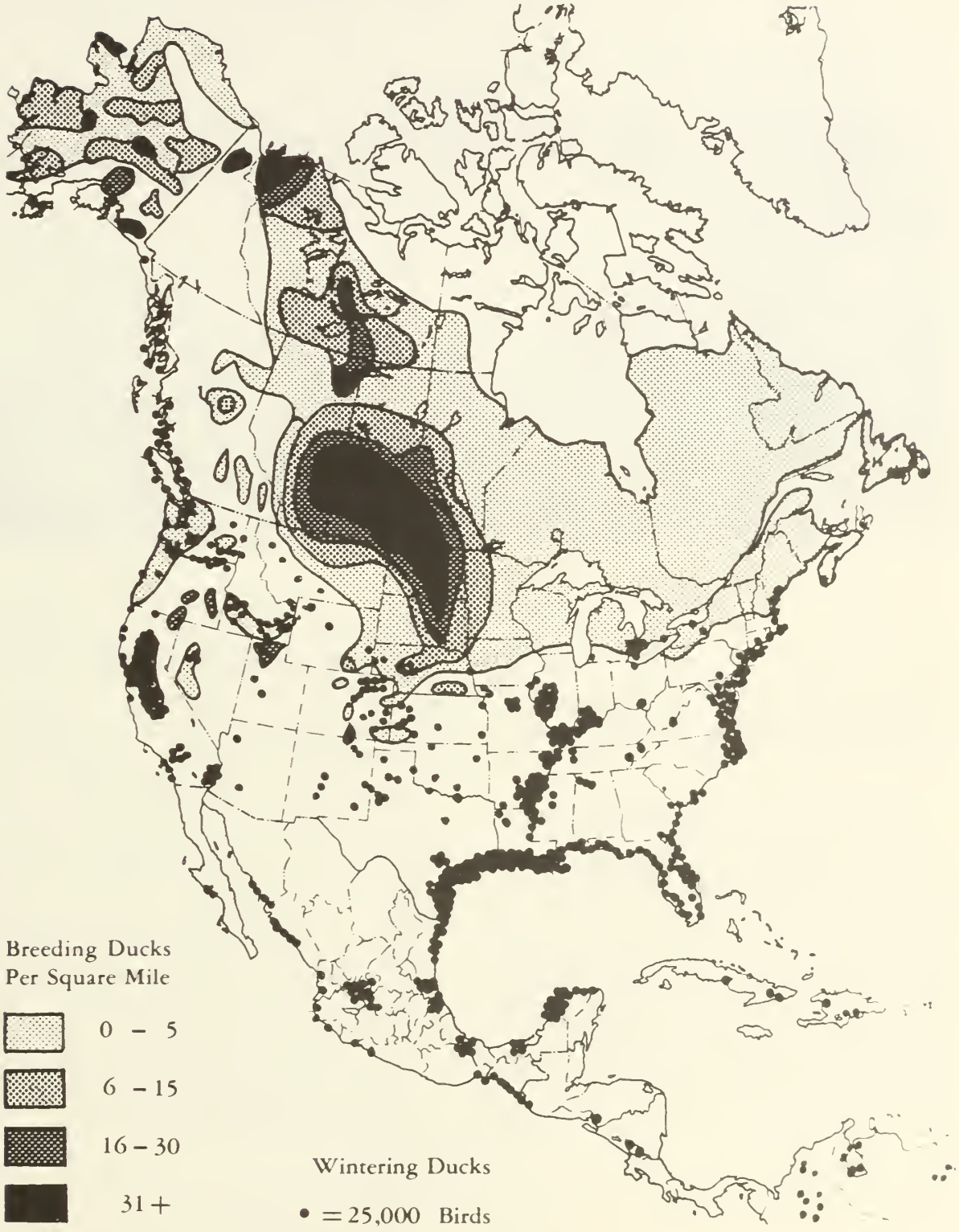

Figure 20

Courtesy Bureau of Sport Fisheries and Wildlife

There are about 3 million waterfowl hunters in the United States. Some hunt in areas of scenic grandeur such as pictured here.

source development reservoirs, and agricultural lands for feeding and resting. Figure 20 illustrates the general distribution of both breeding and wintering ducks in North America; major goose and swan wintering areas generally coincide with these.

Characteristics of Waterfowl Hunters

The proportion of our population that hunts waterfowl varies widely between geographic areas, depending largely on the availability of waterfowl and hunting space, habitat suitable for waterfowl, and the density of human populations. Waterfowling is popular in States such as the Dakotas, which have extensive habitat and relatively few people; in States like Ohio and Pennsylvania, with dense human populations and restricted waterfowl habitat, a much smaller proportion of the public hunts waterfowl.

Age, family income, and occupational distributions of waterfowl hunters are useful characteristics in predicting futures for the sport. In 1970, nearly half of the hunters were 24 years or younger and two-thirds were below age 35. Over half of the hunters had family incomes of less than $10,000 per year. A third had incomes of less than $7,500. The Pacific coastal flyway had the smallest proportion of hunters from the lowest income group and the Central Plains States flyway the highest. Nearly half of the total waterfowl hunters in the Nation were either craftsmen or operatives, 15 percent were professional or technical people and only 4 percent were farmers. White-collar workers were least represented in the Atlantic flyway and most represented in the Central flyway.

Nationally, the nearly 2.9 million waterfowl hunters in 1970 spent about $245 million on their sport, or $84 per person and nearly $10 per day they hunted. Some hunting statistics by individual flyways are summarized below:

	Flyway				
Item	*Pacific*	*Central*	*Mississippi*	*Atlantic*	*United States*
Average hunter's days hunting	6.7	6.9	7.1	5.7	6.7
Average hunter's season duck bag	11.7	8.7	8.0	4.5	8.1
Average hunter's season goose bag	1.1	1.4	.6	.8	.9

Recent Trends in Hunting

Data from the sale of migratory bird hunting stamps, which are required for all waterfowl hunters 16 years of age and older, have the following high-points:

Year	*Number of stamps sold*	*Comment*
1934	635,000	First year stamp required; drought years in mid-1930's
1955	2,370,000	Wet years on major breeding grounds in mid-1950's
1962	1,145,000	Dry years in early and mid-1960's
1971	2,430,000	Wet years on prairie breeding grounds

The harvest of ducks closely paralleled the trend in the number of hunters until the late 1960's when hunters began to increase more rapidly. Both have been strongly related to the condition of the prairie breeding grounds. Statistics on the number of ducks killed are shown in figure 21 for individual flyways. The Mississippi and Pacific flyways are most important, each contributing about a third of the total duck harvest.

The principal species of ducks harvested are listed in table 38. The relative importance of each species in the harvest reflects its general abundance and

Duck harvest by major flyways, 1955 - 1973

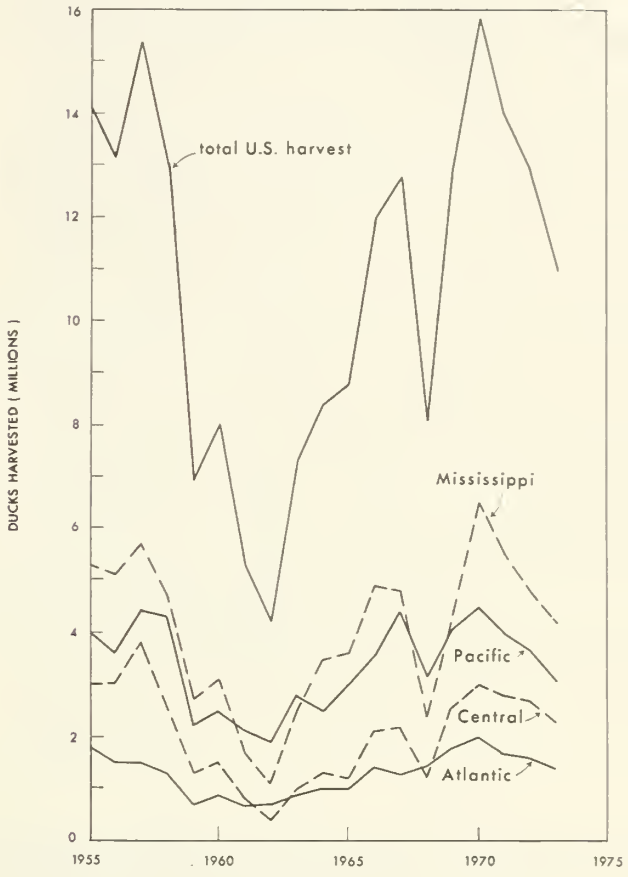

Figure 21

Table 38. *Distribution of duck harvest in the United States, by flyway and species, 1961–70*

(*Percent*)

Species	Flyway				
	Alaska[1]	Pacific	Central	Mississippi	Atlantic
Mallard	23	33	37	36	17
Pintail	20	22	8	4	2
Wood duck	.....	1	2	10	15
American widgeon	15	13	7	5	4
Green-winged and blue-winged teal	18	15	20	17	10
Black duck	.....	.....	(2)	3	21
Gadwall	1	3	10	5	2
Shoveler	5	6	4	2	1
Canvasback	(2)	1	1	1	2
Greater and lesser scaup	4	2	3	7	7
Ring-necked duck	(2)	1	2	6	6
Redhead	.....	1	3	1	1
Goldeneye	3	1	(2)	1	2
Others[3]	11	1	3	2	10
Total	100	100	100	100	100

[1] Based on 1966 to 1970 average harvests.

[2] Trace

[3] Includes Mexican ducks, mottled ducks, buffleheads, ruddy ducks, masked ducks, mergansers, and various sea ducks.

Source: Internal file of Office of Migratory Bird Management, U.S. Department of the Interior, Fish and Wildlife Service.

availability during the hunting season, as well as regulations designed to either increase or decrease the harvest of individual species. In the Atlantic flyway, mallard harvests have exceeded black duck harvests since 1969.

Goose harvest in the United States does not exhibit the radical fluctuations that characterize the duck harvest, primarily because of greater stability of breeding habitat, most of which is in the northern forested and Arctic tundra regions of Canada and Alaska. The harvest of geese generally increased in the United States during the period 1955–73. During that time, the total goose harvest averaged 1,050,000; however, in the last 5 years of the period, the harvest averaged about 1,470,000. This reflects the growth of several individual goose populations, particularly Canada geese of the Atlantic flyway which have increased threefold to fourfold since the mid-1950's, in part because of improved management practices.

Canada geese are most important in the hunter harvest nationwide, including Alaska, but snow geese are slightly more important in the Central flyway. Nationwide, snow geese are the second most important in the hunter's bag and white-fronted geese are third. The distribution of the goose harvest has been similar in the three western flyways, with a harvest in each ranging from 27 to 31 percent of the United States total; the Atlantic flyway accounted for the remaining 16 percent.

Some hunting of whistling swans has been allowed in Utah, Nevada, and Montana in recent years. Since 1970, about 3,500 permits have been issued; the annual harvest has averaged slightly more than a thousand swans.

Projections of Demand to 2020

The demand projections for waterfowl hunting presented earlier in table 37 are graphed in figure 22. These projections show that over the next 15 years or so, demand will increase to about 3.5 million hunters. The most conservative projection suggests the number of hunters will then stabilize; the highest projection suggests there might be about 5 million hunters 45 years from now. In either event it is likely that demand will grow most rapidly in the South and West, with the number of hunters increasing at a slower rate in the Northeastern and North Central States.

Supply of Waterfowl

During the period 1956–62, which included years of both high and low continental waterfowl numbers, the fall flight varied between 77 and 120 million ducks (averaging about 100 million), 5 to 6

Projections of demand for waterfowl hunting

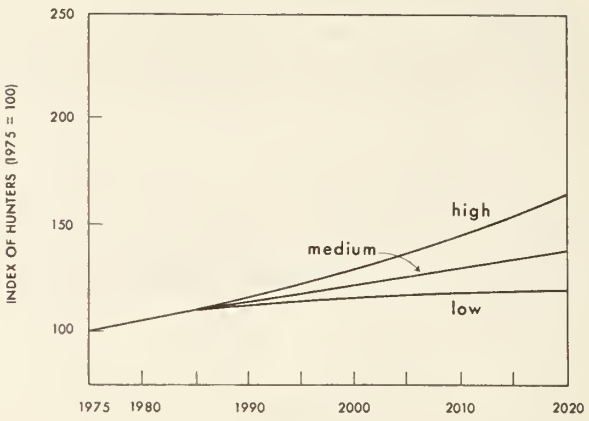

Figure 22

million geese, and 100,000 to 150,000 swans. The 1974 fall flight was estimated at 90 to 100 million ducks and about 6 million geese. An estimated 13 million of these waterfowl originated in Alaska.

The U.S. Fish and Wildlife Service estimates the breeding populations of the most heavily harvested duck species have averaged about as follows:

Species	*Average breeding population 1955–73 (million)*	*Apparent early 1970's trend*
Mallard	8.8	Down
Green-winged and blue-winged teal	7.1	Steady
Greater and lesser scaup	6.6	Steady
Pintail	6.1	Up
Wood duck	3.3	?
American widgeon	3.2	Down
Black duck	2.0	Down
Shoveler	1.9	Up
Gadwall	1.4	Up
Redhead	0.6	Down
Canvasback	0.6	Down

Canada geese have been most numerous (averaging about 1.4 million) and widespread of all geese. Second most abundant have been snow geese (averaging 1.3 million), confined primarily to the three western flyways.

In 1972, the wintering populations of 23 million ducks were distributed among the major flyways in about the same proportion as the duck harvest (figure 21). The 4 million wintering geese were distributed as follows:

Flyway	*Percentage*
Pacific	21
Central	21
Mississippi	38
Atlantic	20

The only swan species hunted in the United States, the whistling swan, has averaged about 100,000 birds, with fluctuations from 67,000 to 157,000. Trumpeter swans, which occur in western Montana, northeastern Idaho, Wyoming, and Alaska and Canada are estimated to number about 6,000 birds.

Habitat Conditions and Management Opportunities

Waterfowl abundance, distribution, productivity, and availability for hunters are dependent upon the quantity and quality of habitat. Some species, such as the mallard, demonstrate great adaptability; others, like canvasbacks, are relatively demanding of specific conditions. Where waterfowl become available to the public largely depends on the distribution of suitable aquatic and upland nesting and feeding areas. Unlike the management of resident game habitat, preservation or creation of habitat in one area may greatly influence the number and availability of waterfowl in other areas.

Wetlands are vulnerable to alteration because most of them can be drained or filled for other land or water uses. An estimated 127 million acres of wetlands once existed in the United States, excluding Alaska and Hawaii; by 1953, only 74 million acres remained intact (excluding 3.8 million acres of overflow and seasonally flooded crop and pasture land) and only about 22 million were judged to be of significant value to waterfowl.[47]

The most critical losses of wetlands have occurred in the North Central States. According to a 1964 inventory, only 2.7 million acres of the most productive wetland types remained in the prairie pothole region of the Dakotas and Minnesota. Since that time, an estimated 350,000 acres have been drained and converted to agricultural land, with many more acres seriously impaired by siltation. Losses of these wetlands, in combination with similar wetland losses in the prairies of southern Canada, are expected to have the greatest adverse impact on maintaining current supplies of those waterfowl most important to American sportsmen.

The increased intensity of farming practices has, in recent years, eliminated much of the critical upland breeding habitat from the prairies, thereby sig-

[47] Shaw, Samuel P., and C. Gordon Fredine. Wetlands of the United States. U.S. Department of the Interior. Fish and Wildlife Circ. 39, 67 p. 1956.

Courtesy Bureau of Sport Fisheries and Wildlife

The Nation's original area of 127 million acres of wetlands has been reduced to 74 million acres. From the standpoint of waterfowl habitat, the most critical losses have come from the drainage of potholes in the prairie region of the North Central States.

nificantly reducing the effectiveness of protecting the wetland base in many areas. During the years when cropland retirement programs were in effect, production of waterfowl and other ground nesting gamebirds such as pheasants was much greater than today because of the millions of acres of high quality cover on the land under those programs.

Other extensive wetland losses have occurred in the bottomland hardwood floodplains in the Southeast, particularly in the Mississippi River Delta region extending south from southern Illinois. Losses are continuing at a rate of a quarter million acres annually as a result of widespread drainage clearing efforts to place more of the fertile floodplain into cropland. Given this trend, by the year 2000 the timbered habitat in this major mallard and wood duck wintering area would essentially be eliminated with only small, scattered tracts remaining.

Key waterfowl habitat areas in Alaska and Hawaii have been identified so they may be preserved in the face of growing pressures from petroleum exploration and development activities and from residential encroachment. These same kinds of pressures have led to damage of tidal and estuary habitats in the Coastal States.

The preservation and enhancement of breeding migration and wintering habitat offers possibilities for maintaining the waterfowl resources as well as increasing hunting opportunities. Flooding of hardwood bottomlands in the Southeast during the fall and winter, either artificially or through natural flooding, significantly increases the habitat base and carrying capacity for waterfowl. Opportunities exist for wildlife extension specialists to show landowners how to improve their land for waterfowl use. For example, fall plowing may be discouraged so that waste grain or green grass shoots are available for feeding waterfowl.

Return irrigation flows are a vital source of water for migrating and wintering waterfowl, particularly in the arid west. Loss of this water source would have serious impacts on waterfowl; providing additional water during dry seasons in western areas would significantly increase the habitat base, particularly in the two western flyways. Other practices for improving food and cover include mowing, prescribed burning, disking, planting, etc., and—on a limited scale—managed livestock grazing.

Federal and State programs have been responsible for preserving of the prairie pothole habitat in the Dakotas, Minnesota, Nebraska, and Montana through a combination of fee purchase of key tracts and the acquisition of wetland easements. The easements, mostly perpetual, provide an economic incentive to the landowner for not draining, burning, filling in, or leveling his wetlands while allowing him to utilize the ponds for other normal agriculture practices such as grazing, haying, and cultivating when the ponds are naturally dry. Short-term legal arrangements are most acceptable to landowners who do not wish to obligate their land in perpetuity, but the temporary nature of such programs increases the future uncertainty of the wetland base.

Because they are, to a substantial degree, funded through hunter license fees, State, private, and to some extent Federal habitat acquisition and development programs are dependent on the continued availability of a harvestable surplus of waterfowl. The U.S. Fish and Wildlife Service administers about 4.0 million acres of migratory bird refuges throughout the four flyways and another 1.4 million acres of small waterfowl production areas located mostly in glaciated prairie pothole region. As of 1966, State conservation agencies controlled approximately 4.5 million additional acres of land and water having major value to waterfowl, much of which is open to public hunting. About half of the acreage was owned and the rest under lease or other agreement. About 11,000 private waterfowl hunting clubs controlled, through leases and ownership, a minimum of 5.2 million acres of waterfowl habitat. Many of these areas provide opportunities to help ensure healthy waterfowl populations through cooperative programs.

Although primary emphasis in the management of wetlands has been to benefit waterfowl, wetlands contribute substantially to the habitat requirements of many other species of wildlife. Among the wildlife populations associated with wetlands are 19 species of small game, seven species of big game, 11 species of fur animals, the alligator and a variety of nongame birds.[48] There is probably no other kind of wildlife habitat where management effort benefits such a wide range of wildlife, including nongame species.

Examples of activities that would help correct current problems and minimize future problems facing waterfowl populations can be grouped in the following fashion:

[48] Shaw and Fredine. op. cit.

Management activities	*Examples*
Restrictive—limiting human activities	Provide protective zoning of coastal marshes; discourage draining of marshes.
Coordinating—coordination with other resource management	Provide information to farmers on implications of their practices; schedule release of impounded waters for maximum waterfowl benefit.
Positive—expenditures explicitly for waterfowl production	Accelerate purchases of long-term easements of privately owned wetlands; improve upland food and cover through mowing, disking and planting.

Fishing

There are numerous species of fish in inland waters which are harvested by fishermen. These include resident fish that complete their life cycles in freshwater and anadromous fish that are hatched in freshwater, migrate to saltwater, and return to freshwater to spawn.

Courtesy Bureau of Sport Fisheries and Wildlife

Fishing is one of the most popular and fastest growing outdoor recreation activities. Crowding does, of course, detract from the enjoyment of the experience.

Characteristics of Fishermen

Recreational fishing.[49]—Fishing is one of America's most popular and fastest growing outdoor recreation activities. There are roughly twice as many fishermen as hunters. In 1970, there were over 33 million fishermen, who were categorized as "substantial" anglers, fully 21 percent of the Nation's population, 12 years of age and over. This represented an increase of 60 percent over 1955.

The Outdoor Recreation Resources Review Commission[50] noted that fishing was a preferred outdoor activity for a third of all Americans in 1960; it was second in popularity only to swimming.

In 1970, about 29 million people fished in freshwater and over 9 million did at least some of their fishing in saltwater.[51] As indicated in the tabulation below, most fishermen were in the lower income groups:

Income group	*Freshwater fishermen (percent)*	*Saltwater fishermen (percent)*
Less than $7,500	38	32
$7,500—$10,000	20	19
$10,000–$15,000	26	30
More than $15,000	16	19

In the course of the year 1970, fishermen spent about $5 billion on their sport. Freshwater fishermen individually spent almost as much as did saltwater fishermen ($127 vs. $129) but fished nearly twice as often. Saltwater fishermen spent more dollars on the average annually than any other type of consumptive users of fish or wildlife except big game hunters. One in every nine Americans who earned more than $25,000 was a saltwater fisherman, by far the highest proportion in that income class for any hunting or fishing activity.

While freshwater fishermen were somewhat younger than saltwater fishermen, in both instances in 1970 about a third were less than 25 years old and more than two-thirds were less than 45 years old. Somewhat more than half of all saltwater fishermen were white-collar workers; more than half of the freshwater fishermen were blue-collar workers. About one-fourth of all fishermen were women.

Fishing tends to be more popular in the less urbanized regions of the country than in the highly urbanized and industrialized areas. A higher ratio of anglers to population is generally found in the Southern States, Northern Plains States, Rocky Mountain States, and Pacific Coastal States, but the fishing rates tend to vary more by size of place of residence than they do by region. This probably simply reflects greater fishing opportunities. Rivers, lakes, streams, and reservoirs all attract freshwater fishermen:

Type of freshwater	*Number of fishermen (million)*
Reservoirs	8.3
Artificial ponds	3.9
Natural lakes and ponds	8.0
Rivers and streams	9.2

[49] Dailey, Thomas E. Human behavior aspects of sport fishing: an annotated bibliography. U.S. Department of Agriculture Forest Service, Pacific Northwest For. and Range Exp. Sta., Portland, OR., Gen. Tech. Rpt. (In process.)

[50] Outdoor Recreation Resources Review Commission. National recreation survey, ORRRC Study Report 19. Washington, D.C. 1962.

[51] Because anadromous fish make up less than 4 percent of the total saltwater recreational catch (nearly half the recreational catch on the Pacific Coast), descriptive information for all saltwater fishermen may be misleading. Further, those seeking anadromous fish in freshwater are included with freshwater fishermen.

Saltwater fishermen pursue their recreation along all of the coasts. In 1970, they were distributed as follows:

Area	Number of saltwater fishermen (million)	Annual recreation days per fisherman (number)	Annual expenditures per fisherman (dollars)
Atlantic Coast	5.0	12	127
Gulf Coast	2.3	15	178
Pacific Coast	2.2	8	84
Total/average	9.5	12	129

Commercial fishing.—In addition to recreational fishing, there were 231,000 persons employed in the Nation's commercial fishing industry in 1971.[52] Of these, 140,000 were fishermen; the remaining 91,000 were employed in approximately 3,700 fishery shore establishments. Of the 10,300 commercial fishing vessel operators with paid employees in 1967, less than 1,000 had five employees or more.[53] From the data available, it is not possible to identify the number of commercial fishermen by the various fisheries. However, based on total catch, the three coastal fisheries are approximately equal; inland fisheries are less important, as shown below:

Fishery	Catch (billion pounds)
Atlantic Coast	1.7
Gulf Coast	1.6
Pacific Coast	1.2
Inland	.1
Total	4.6

Recent Trends in Fishing

Demands for opportunities for recreational fishing, as measured by the number of participants, have increased substantially during the past two decades. Freshwater commercial fisheries have also expanded and saltwater commercial fisheries dependent on anadromous fish populations seem limited only by the number of fish available.

Recreational fishing.—Data from four successive national surveys of fishing indicate that over the past 15 years participation has rapidly increased both in terms of the number of participants and in days fished. During this period, the percentage of freshwater fishermen in the total population increased at the rate of 2 percent per decade.

Freshwater fishing tends to be popular with a broad spectrum of the population because of the wide range of opportunities. The required equipment can range from very simple tackle to that which is very expensive. The demands on skill and physical exertion vary considerably depending on the type of fishing engaged in.

Participation in saltwater fishing has increased even more rapidly. Between 1960 and 1970, the catch (in pounds) by saltwater anglers increased by over 14 percent. The four successive national surveys of fishing indicated that the number of recreational saltwater fishermen more than doubled between 1955 and 1970, and the number of recreation days spend in saltwater fishing for sport showed a similar gain. This was the fastest rate of increase of any consumptive recreational use of fish or wildlife during that period.

In 1970, anadromous fish accounted for about 4 percent of the total recreational catch by saltwater sport fishermen. The number of fishermen and their catch by species and geographic area are presented in table 39. Washington had the largest recreational catch of salmon, followed by Oregon, California, and then Alaska.[54]

Commercial fishing.—Trends in certain kinds of commercial fishing are similar to those for recreational fishing. The warmwater channel catfish industry began about 1960 and has been rapidly expanding for the past decade. It has remained centered in the lower Mississippi Delta, although 1,700 farms and 1,300 fee-fishing operations are spread over 37 States. The center of coldwater trout raising shifted westward about 40 years ago and is now centered in Idaho. This industry has been expanding since the end of World War II and now is reported to include 200 farms and perhaps 1,000 fee-fishing operations. Crayfish harvesting has been important since the early 1900's; today half the total harvest comes from intensively cultivated farms in southern Louisiana.

Fifty million pounds of freshwater fish with a commercial value of $70 million are raised in controlled habitats and sold for human consumption annually in the United States. In addition, the uniquely American industry of raising bait fish for recreational uses now has annual sales of over $100 million. Perhaps as many as 30 warmwater and 20 coldwater fish species are raised and sold for these two purposes.[55] In terms of surface acres of waters devoted to producing minnows for bait fish, Arkansas and Minnesota are the leading States.

[52] U.S. Department of Commerce, National Marine Fisheries Service. Fisheries of the United States, 1974. Current Fishery Statistics No. 6700. Washington, D.C. 1975.

[53] U.S. Bureau of the Census. Census of commercial fisheries, 1967. Series FC 67–1. Washington, D.C. 1970.

[54] Salo, Ernest O. Anadromous fish. *In* Salmonid Management. Trout Unlimited 15(1): 12–21. 1974.

[55] Klantz, George W., and John G. King. Aquaculture in Idaho and nationwide. Idaho Water Resources Institute, Univ. of Idaho, Moscow, Idaho. 86 p. plus appendix. 1975.

Table 39. *Recreational saltwater fishing for the anadromous species in the United States, by principal species, 1970*[1]

Species	Number of fishermen		Number of fish caught		Proportion taken in bays, sounds, and tidal portions of rivers
	Atlantic Coast[2]	Pacific Coast[3]	Atlantic Coast[2]	Pacific Coast[3]	
	Thousands	*Thousands*	*Thousands*	*Thousands*	*Percent*
Salmon, chinook	.....	218	.....	912	47
Salmon, coho	.....	321	.....	1,447	34
Salmon, pink	.....	54	.....	162	57
Shad, American	69	3	1,714	69	95
Smelts	4	104	649	4,812	94
Steelhead	.....	116	.....	724	90
Striped bass	793	153	14,237	2,031	88
Trout, cutthroat	.....	48	.....	1,100	99
Trout, Dolly Varden	.....	27	.....	199	100

[1] Excludes fish caught in freshwater portions of river systems.

[2] Principally from New Jersey to North Carolina.

[3] Northern California to Washington plus Alaska, except 10 percent of smelt taken in Southern California.

Source: Deuel, David G. *Saltwater angling survey—1970*. U.S. Department of Commerce, National Marine Fisheries Service. Current Fishery Statistics No. 6200. Washington, D.C. 1973.

Since 1950, the total annual commercial catch of saltwater fish has been fairly stable at just under 5 billion pounds, but the total value of the catch has doubled. In 1974, the domestic value of Pacific salmon reached $121 million, second only to the value of shrimp. However, the salmon catch was the smallest since 1915. There were sharp decreases from 1973 in the harvests of chinook, chum, and pink salmon that were only partially offset by moderate increases in sockeye and coho landings. A long-term high demand for salmon products, coupled with a decreasing catch, has driven prices up substantially since the late 1960's.[56]

Currently, there are a series of decisions being made in the Federal court system that could have a significant impact on the fate of both the recreational and commercial salmon fisheries in the Pacific Northwest. These revolve around the definition of the rights of American Indians in utilizing these fish resources. It seems certain there will be a new view on who can use the fisheries and how; there may also be implications for changes in the way they are managed.[57]

[56] Fisheries of the United States, 1974. Current Fishery Statistics, No. 6700. op. cit.

[57] Elke, Richard C. An analysis of United States vs. Washington—Indian treaty fishing rights in the State of Washington. Cong., Res. Service, Library of Congress, Wash., D. C., Report AP 261, 16 p. 1974.

Crouse, Carl N. The direction of Indian treaty interpretation. p. 1–26, *in* Report of the Indian Relations Committee, 64th Annual Convention of International Association of Game, Fish and Conservation Commissioners, 1974.

Richards, Jack. The economic impact of the Judge Boldt decision. Northwest Region, National Marine Fisheries Service, U.S. Department of Commerce, Seattle, Wash. 11 p. plus 12 tables. 1975.

Projections of Recreational Demand to 2020

Projections based on past trends in participation rates and the assumed increases in population indicate that future demands for freshwater and saltwater fishing is likely to grow rapidly (table 37, figs. 23 and 24). Because of high participation rates, the assumptions about the level of future population make a substantial difference. Regardless of the assumption, though, it appears that the growth in demand will be large. A doubling or tripling of demand over the next 45 years would be little more than has already been experienced in just the past few decades.

Projections of demand for freshwater fishing

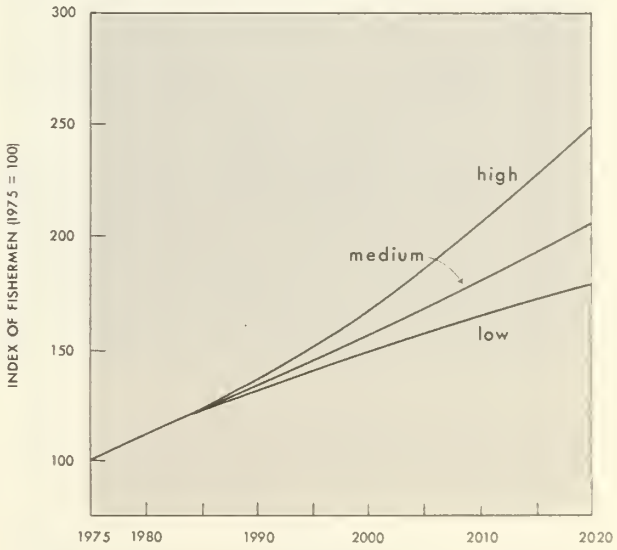

Figure 23

Projections of demand for recreational saltwater fishing

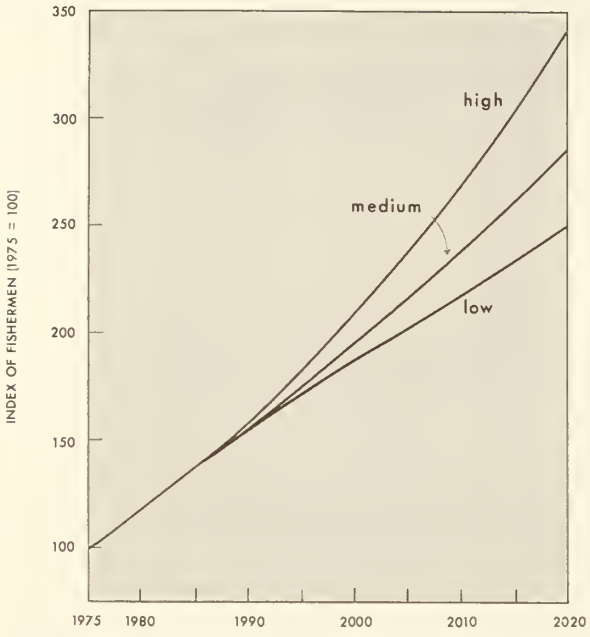

Figure 24

Supply of Fish and Management Opportunities

Freshwater fish.—In 1960, it was proposed that anticipated increases in demands for recreational fishing could best be met by accommodating one-third of those increases in each of three ways:[58]

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During the 1960's 3.3 million acres of farm ponds, fishing lakes, and reservoirs were constructed. These waters have contributed in an important way in meeting rising demands for freshwater fishing.

1. By adding new fishing waters to present stocks. It was estimated that the acreage of impounded fishing waters would have to be doubled from 10 to 20 million acres by the year 2000, with half that increase coming by 1975. During the 1960's, 3.3 million acres of reservoirs, farm ponds, and fishing lakes were constructed. If this pace has been maintained in the 1970's, these water surface area goals are being met.[59]

2. By improving the management of existing fishing waters. Since three-quarters of freshwater recreational fishing is in warmwater fish habitats and since intensive management techniques are more highly developed for enclosed bodies of water than for free-flowing streams, warmwaters have received the most attention. Between 1953 and 1970, more than a million acres of fishing waters were renovated and restocked. Since 1956, more than a million acres have been made newly accessible to fishermen.[60] In lake and reservoir management, undesirable fish have been replaced with desired species, frequently in conjunction with the construction of water impoundments to assure that favorable water levels are maintained. There has been fertilization to stimulate food production and installations of nesting and rearing cover.[61] Probably the point has not yet been reached where increases in water quality counterbalance continuing pollution and deterioration, but the upward trend in renovation activities plus relatively recent Federal and State water quality laws and standards augur well for the future.

3. By diverting freshwater fishermen to relatively unused coastal areas. At the present, however, it is not known how much additional fishing pressure these areas can support.

Although it appears likely that with the necessary investments in management programs the projected demands for stillwater fishing can be met, there are some problems and limitations. There is a pressing need to develop reservoirs near population centers to provide fishing opportunities for urban residents. Where tried, these strategically located and intensively managed reservoirs have supported very high levels of fishing pressure. However, the amount of rivers and streams cannot be increased and streams are the most susceptible of the aquatic environments to encroachment and destruction. Municipal and industrial pollution, erosion, siltation, impoundments, stream channelization, and other factors reduce this

[58] Outdoor Recreation Resources Review Commission. Sport fishing—today and tomorrow. Study Rpt. No. 7, 84 p. Washington, D.C. 1962.

[59] It should be noted that these gains in opportunities for stillwater fishing have, in part, been at the expense of a reduction in fishing opportunities along free-flowing streams.

[60] Martin, B. Facts don't lie—fishing is better than ever and SFI has figures to prove it. Fishing Tackle Trade News. 6 p. August 1972.

[61] Dunst, Russell C. Survey of lake rehabilitation techniques and experiences. Department of Natural Resources, Madison, Wis., Tech. Bull. 75, 179 p. 1974.

resource base. And in some areas, fishing pressures are already greater than can be supported by the native fish resources. While supplemental stocking has been widely used, for some fishermen the intangible quality of the fishing experience must suffer as the number of anglers increases, especially on cold-water streams and high-mountain lakes.

Anadromous fish.—Several kinds of forces have had adverse impacts on anadromous fish populations. For example:

—Commercial overfishing on the Pacific Coast by Americans through the 1950's so reduced salmon stocks that they have never recovered (Russian and Japanese salmon fishing is still essentially unregulated);[62]

—Since the early 1900's, 1,500 miles of river habitat of the American shad in 23 Atlantic Coastal States have become unavailable or unsuitable because of water pollution or water use developments;

—An earthquake in the mid-1960's severely damaged 180 pink and chum salmon streams in Prince William Sound, Alaska, causing an estimated $3 million annual loss; and

—Dams on the Columbia River and its tributaries, all the way into Idaho and Montana, have substantially decreased the ability of salmon to reach the ocean and return to their natural spawning areas.

In total, a substantial portion of the spawning and rearing areas once used by anadromous fish is no longer available because of water diversions, hydroelectric dam construction and water degredation caused by industrial and agricultural activities. To offset these losses, most anadromous fisheries (except in Alaska) are essentially supported through artificial propagation. In Washington and Oregon, there are now nearly 100 hatchery and pond rearing facilities for chinook and coho salmon and for steelhead.[63] The very existence of these facilities suggests that preservation of remaining natural habitats is constantly becoming more important.

Habitat degradation primarily occurs when, as a result of land management or land development activities, vegetative cover along streambanks that greatly influences water temperatures is destroyed, silt or organic matter or harmful chemicals enter the streams, or obstructions close the streams to fish movements. Timber management and logging and the accompanying road construction are the activities that most commonly affect the smaller streams that provide much fish habitat. While there occasionally may be an opportunity to improve fish habitat through these activities—such as by thinning streambank vegetation in dense forest stands so the increased water temperature will promote increased production of algae and aquatic insects that provide food for fish—most often the problem is to avoid harming the fish habitat.[64]

Perhaps the best known successes in increasing anadromous fish populations have been through the introduction of nonnative fish, such as the striped bass on the Pacific Coast and salmon in the Great Lakes. By 1973, about 50 million coho and chinook salmon had been introduced in the latter program.[65] The annual recreational catch of salmonids from Lake Michigan alone now nearly equals the total sport catch of salmon and steelhead in Washington, Oregon, California, Alaska, and Idaho combined.[66]

Finally, it should be noted that the conditions in our freshwater streams and rivers have implications for more than the anadromous fisheries. Table 40 shows that nearly a half billion dollars worth of fish and shellfish—almost half of the value of all the seafood harvested by the United States—is harvested within 3 miles of our shores. The future of a substantial portion of all our fisheries is at least partly dependent on how we treat our freshwater and tidal water resources.

The management opportunities for maintaining or developing acceptable anadromous fish populations

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[62] Naab, Rondal C., and Jim H. Branson. Enforcement and surveillance needs under extended fisheries jurisdiction. p. 86–90, *in* Transactions of the 40th North American Wildlife and Natural Resources Conf., Wildlife Management Institute, 1975.

[63] Roberts, Richard. Development of fisheries regimes under extended fisheries jurisdiction: salmon resources. p. 59–62, *in* Transactions, 40th North American Wildlife and Natural Resources Conf., Wildlife Management Institute. 1975.

[64] Meehan, William R. The forest ecosystem of southeast Alaska—3. fish habitats. U.S. Department of Agriculture Forest Service, Pacific Northwest For. and Range Exp. Sta., Portland Ore., Gen. Tech. Rpt. PNW–15, 41 p. 1974;

Fredriksen, R. L., D. G. Moore, and L. A. Norris. The impact of timber harvest, fertilization, and herbicide treatment on streamwater quality in western Oregon and Washington. p. 283–312 *in* Forest Soils and Forest Land Management, B. Bernier and C. H. Winget (eds.). International Scholarly Books Services, Inc., Portland, Ore. 1973; and

Gibbons, Dave R., and Ernest O. Salo. An annotated bibliography of the effects of logging on fish of the western United States and Canada. U.S. Department of Agriculture Forest Service, Pacific Northwest For. and Range Exp. Sta., Portland, Ore., Gen. Tech. Rpt. PNW–10, 145 p. 1973.

[65] Crowe, Walter R. Great Lakes Fishing Commission: history, program and progress. Great Lakes Fishery Commission, Ann Arbor, Michigan, 23 p. 1975.

[66] Great Lakes Basin Commission. Great Lakes Basin framework study: Appendix 8—fish. 290 p. Ann Arbor, Michigan. 1975.

Table 40. *Value of commercial landings of fish and shellfish caught within 3 miles of the shore in the United States, by species, 1974*

Species	Value of within-3-mile catch	Proportion of value of total U.S. catch
	Million dollars	*Percent*
Fish:		
Pacific salmon	102.5	85
Other	131.5	32
Subtotal	234.0	44
Shellfish:		
Clams	29.5	76
Crabs	38.3	46
Lobsters	32.0	55
Oysters	33.6	100
Shrimp	42.8	22
Other	14.1	58
Subtotal	190.3	44
Total	424.3	44

Source: U.S. Department of Commerce. Fisheries of the United States, 1974. op. cit.

can be illustrated for each of the broad and partially overlapping categories listed below.

Management activities	*Examples*
Restrictive—limiting human use	Control of industrial wastes and pesticides; removal of artificial barriers; intensified control of commercial fisheries.
Coordinating—coordination with other resource uses	Minimize adverse impacts of logging, road construction, grazing, and recreational activities on stream habitats; inclusion of fish ladders or other passageways in water resource developments.
Positive—expenditures explicitly for anadromous fish production	Hatchery production; introduction of desirable species to new waters; development of new spawning areas and rehabilitation of rearing areas in streams.

Range

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Range includes all rangelands and forest lands that provide forage for grazing and browsing animals.

This chapter includes (1) projections of demand for range as a source of livestock grazing, (2) a description of the Nation's range resource base and its current use and productivity, and (3) a summary of opportunities for future range development and management. Most of this information has been condensed from "The Nation's Range Resources—A Forest-Range Environmental Study,"[1] published by the Forest Service in 1972. The projections of demand in that study have been revised here because of recent changes in expectations about growth in population, prices, availability of livestock feeds, and energy costs. Much of the discussion of issues relating to demand is based on analysis done in conjunction with a 1974 study reported in "Opportunities to Increase Red Meat Production from Ranges of the United States."[2]

In an earlier chapter, rangeland and forest land were defined according to the life form of the dominant vegetation of the area. Those definitions are independent of the use made of the area. The definition of range, on the other hand, is use-oriented and includes "all land producing native forage for animal consumption, and lands that are revegetated naturally or artificially to provide a forage cover that is managed like native vegetation."[3] Range, therefore, includes all rangelands and those forest lands (commercial and noncommercial) that will continually or periodically, naturally or through management, support an understory of herbaceous or shrubby vegetation that provides forage for grazing and browsing animals. It also includes those lands on which more productive species have been introduced *but* which are managed as native species.

The key elements in the definition of range are (a) the forage is produced by native species and (b) if introduced species are present, they are managed as if they were natives. This precludes annual or more frequent cultivation, seeding, fertilization, irrigation, and other similar practices applied on improved pastures.

Frequently, "range" is termed "forest-range" to emphasize that both forest lands and rangelands are included. In this chapter, the two terms are used interchangeably.

The Role of Range

Range grazing had its beginning on the grasslands and steppes of the Middle Eastern part of Asia, where for more than 4,000 years, some areas have had continuous livestock grazing use. At present, almost half of the earth's land surface is used for grazing, and the great bulk of animal feed comes from such lands in the economically developing countries.

The term "range" originated with the early settlers in Virginia who allowed their livestock to "range freely" in the woods. From this, the term range came into common usage, meaning a kind of unfenced land upon which livestock graze. Although often herded, the livestock on these lands were expected to balance their own diets from forage and browse and to find shelter from hot suns and winter blizzards as necessary.

Much of the Nation's range has been grazed by domestic stock for at least 100 years—some of it for as long as 450 years. Ponce de Leon is said to have introduced livestock to Florida in 1519. By 1614, the Colony of Jamestown, Virginia, was " . . . furnished with two hundred neate cattell, as many goates, infinite hogges in heards all over the woods, ..."[4] Before that, native herbivorous animals such as buffalo, antelope, elk, and deer grazed ranges for millenia. With the coming of Europeans and their livestock, grazing pressure increased, and over two or three decades—especially late in the 1800's and early 1900's—the vegetation on many western ranges deteriorated. Parts of the range were abused and overgrazed in the Southwest by livestock, primarily sheep, as early as 1700. While many ranges have recovered, evidence of overgrazing still persists. Some ranges, including forested areas throughout the United States, are still being grazed improperly.

Overgrazing was also widespread on Federal lands. Settlers and itinerant stockmen grazed free of control on public domain lands (now called National Resource Lands) until passage of the Taylor Grazing Act of 1934. Distances over which herds of cattle, sheep, and goats grazed were determined largely by the amount and quality of forage and the number and location of watering places controlled by the operator. Conflicts often arose between stockmen over the use of these lands when several claimed the same waterhole or a particular "range" for grazing their livestock. Conflicts also developed between stockmen and homesteaders who fenced and cultivated the land. Other public domain lands—which, beginning in 1891, were designated as Forest Reserves (now, National Forests)—also were grazed without control until 1905 when the Forest Service began a program of grazing control and management.

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[1] U.S. Department of Agriculture, Forest Service. The Nation's range resources—a forest-range environmental study. Forest Resour. Rep. 19, 147 p., illus. 1972.

[2] U.S. Department of Agriculture, Inter-Agency Work Group. Opportunities to increase red meat production from ranges of the United States, Wash., D.C. 1974.

[3] American Society of Range Management (now The Society for Range Management). A glossary of terms used in range management, 32 p. Portland, Oreg. 1964.

[4] Hamer, Ralph. A true discourse of the present estate of Virginia. Reprinted from the London edition, 1615, with an introduction by A. L. Rowse, Virginia State Library, 1957, Publ. No. 3. 1615.

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In addition to overgrazing, part of the Nation's range has been affected by cultivation. During the settlement era, tens of millions of acres of rangelands in the West were planted to wheat and other crops. Many of these lands, marginal for the production of crops, were abandoned following periods of drought and low prices. Conservation efforts beginning in the 1930's resulted in the return of much of these marginal croplands to permanent grass cover.

In the Western States, most of the present range is characterized by scarce and sporadic precipitation, rough topography, and shallow, rocky soils. These characteristics preclude cultivation and thus competition between livestock and other agricultural enterprises is minimal.

Production per unit of land area is low relative to other agricultural lands, and is subject to greater year-to-year fluctuations associated with changes in weather. Capital inputs to the range per acre also are lower than on the higher producing lands, but relatively large land area and total investment are required to support an economic operating unit. On the other hand, the amount of labor per head of livestock is relatively low on range and the need for fertilizer and fossil fuel inputs per unit of production is small compared with amounts required in production of crops such as corn, wheat, and soybeans.

Range grazing is generally only one of the many inputs in beef cattle and sheep production. It is often accompanied by grazing from improved pasture, hay cut from the same land that is later grazed, other forages from croplands, and high-energy concentrates, such as cottonseed meal and corn. Range, too, often complements other forage sources in a seasonal sense, being grazed during times when other forage sources are dry or otherwise not productive. Where public range and privately owned land are intermingled, a common occurrence, efficient resource use depends upon coordination of management. Therefore, the quantity and season of grazing use available on public lands has a major influence on the successful use of private lands.

Since 1950, there has been a continual reduction in the quantity of land available for forestry and agricultural uses including range grazing. Land withdrawn from agricultural production is now in urban, transportation, recreation, parks, wildlife areas, national defense, industrial, public installations, and facility uses. This trend in reduction in land resources available for agricultural purposes is expected to continue.

In addition, use of range for livestock, meat, and fiber production often is influenced by pressure to use the land for additional purposes including timber production, watershed protection, wildlife habitat, scenic beauty, and recreation.

Range grazing is rarely totally separated from other uses of the range or from other obligations. Therefore, potential demand for integrated use of the range is high in many areas, and conflicts of interest among users and uses can and do occur.

Proper livestock grazing is compatible with, or even complementary to, many other resource uses. Many species of wildlife can benefit from grazing systems that promote native plants, thereby enhancing their food supplies and other habitat requirements. Cattle grazing during spring and early summer can reduce competition from grasses, allowing browse plants to grow more vigorously for increased big game feed during the winter. On many grass-shrub ranges, livestock grazing can reduce the potential of fire through consuming vegetation, thus preventing a build-up of fuel. Esthetic values of landscapes can be enhanced through use of grazing systems and manipulation of vegetation that creates contrast in vegetation color and form. In addition, presence of livestock in the landscape increases the recreational experience of many people, especially urban dwellers.

The increasing demand for nongrazing outputs is controlled by the same factors of population, income, trade, and quality of life which control the increased demand for grazing. Therefore, planning for range development and management must consider all of the increasing demands.

The location and concentration of public lands are significant elements in the demand for range grazing. Because of this concentration, investment in public range can be a means of improving rural development and stability.

When range is used for such purposes as grazing, recreation, parks, wilderness, or wildlife, there is also a national public desire or intent that range productivity be maintained to serve needs of future generations. In addition, there is a desire to preserve the natural characteristics of range including its native flora and fauna.

The Demand for Range Grazing

Cattle and sheep account for nearly all the grazing by domestic livestock on the Nation's forest-range. Thus, one of the important determinants of demand for forest-range grazing in coming decades will be the demand for red meat (beef, veal, lamb, and mutton). Changing price relationships among alternative feed sources and technological changes will also be important.

Demand for Red Meat

The demand for red meat depends primarily upon population and income growth. The projected increases in these determinants presented in the Basic Assumptions chapter of this study indicate the like-

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Growing population and income indicate that the demand for red meat is likely to rise in the decades ahead.

lihood of continued and substantial growth in demand in the decades ahead.

Demand could be significantly affected by other forces and particularly changes in consumer preferences for beef. Other sources of protein have frequently been proposed as alternatives to the protein provided by beef, particularly for U.S. domestic consumption. It is generally considered more efficient for people to consume grain products directly rather than to feed grain to livestock and then consume the livestock products. Grains consumed as milled or baked products provide two to five times more calories for human consumption than are available if the grain is converted to livestock products. Protein and other nutrients available from livestock products are not necessarily more nutritious than those in cereals.

In the United States, dry beans and peas, nuts, and soya flour provided the human population with 5 percent of its protein consumption in 1973, flour and cereal products provided almost 18 percent, and meat, poultry and fish provided over 41 percent.[5] In recent years, per capita consumption of peas, nuts, and soya products has been increasing while per capita consumption of flour and cereal products has been decreasing. The only major, permanent penetration of the red meat market in the United States has been by soy protein extenders which have replaced part of the meat in processed items.

In general, shifts in use of grains versus meat have been strongly influenced by changes in relative prices. Grains are the major source of food for the world's poor, supplying 60 to 75 percent of the calories consumed. In view of the rapid growth in the number of grain consuming people, world demands seem likely to continue to move up rapidly. Costs also seem likely to rise, largely in response to the rising costs of fertilizers and the use of increasing acreages of lower productivity lands.

Among meats—beef, veal, pork, lamb, mutton, chicken, and turkey—beef composed 50 percent of the total per capita consumption in 1970–72. This strong consumer preference is expected to continue. This preference, along with rising grain prices—chicken and turkey production is almost entirely based on grains in contrast to beef which can be produced from forage—indicate that white meats are unlikely to substitute in any significant way for beef.

With consideration of the above factors, per capita demand for beef and veal in the United States is projected to increase from the 1970–72 average of 116.8 pounds (carcass weight) to 127.8, 150.7, and 152.7 pounds for 1980, 2000, and 2020, respectively (table 41). Lamb and mutton demand per cap-

[5] U.S. Department of Agriculture. Agricultural Statistics. 1974.

Table 41. *Average per capita meat consumption in the United States, 1970–72, with projections of demand to 2020*

(*Pounds*)

Kind of meat	Consumption—1970–72 average	Projected demand					
		1980		2000		2020	
		High	Low	High	Low	High	Low
Beef and veal	116.8	127.8	125.0	150.7	135.0	152.7	140.0
Lamb and mutton	3.2	2.6	2.1	2.5	1.7	2.3	1.7

Sources: 1970–72 average—U.S. Department of Agriculture, Economic Research Service. *Livestock and meat situation*. Vol. 202. April 1975. Low projections—U.S. Water Resources Council OBERS Projections, Regional Economic Activity in the United States. Vol. 1. April 1974. High projections—U.S. Department of Agriculture, Economic Research Service. 1975. (Unpublished data.)

Table 42. *Average per capita net imports of meat into the United States 1970–72, with projections to 2020 under high and low export policies*

(*Pounds per year*)

Kind of meat	Average net imports, 1970–72	Projected net imports					
		1980		2000		2020	
		High	Low	High	Low	High	Low
Beef and veal	8.41	6.10	9.15	6.72	11.16	8.84	10.36
Lamb and mutton	0.57	0.85	0.85	1.05	1.05	0.95	0.95

Source: U.S. Department of Agriculture, Economic Research Service. *Livestock and meat situation*. Vol. 202. 1975.

ita is projected to decrease from the 1970–72 average of 3.2 pounds to 2.6, 2.5, and 2.3 pounds for the same projection years.

Imports and exports.—Part of the demand for beef and veal and lamb and mutton in the United States will be met by imports. Imports have been rising fairly rapidly. Exports have also been rising, but more slowly than imports. These trends are expected to continue. As a result, the net import of beef which averaged 8.4 pounds per capita in 1970–72, could reach as much as 11.2 pounds by year 2000, an increase of 33 percent (table 42). Net imports of lamb and mutton show substantial growth, rising from an average of 0.57 pounds per capita in 1970–72, to a projected level of 1.05 pounds in 2000.

Although net imports are projected to rise, the increase is substantially less than the growth in the demand for beef and lamb. Imports in 2000 represent only 7 to 8 percent of the per capita demand for beef and 40 to 60 percent of the per capita lamb demand in 2000. Imports are not expected to provide sufficient meat to meet increasing demands. Thus, the Nation will have much larger demands for domestically produced meat, and, therefore, increasing demand for forest-range grazing.

Changing Price Relationships Among Alternative Livestock Feeds

In addition to the growth demand for beef and lamb, the actual growth in demand for range grazing will be affected by changes in the relative costs of alternative feeds. Beef and lamb can be produced in a variety of processes utilizing a wide variety of different feeds. Production based entirely on grazed forage until the animal reaches slaughter weight is one process and obviously uses the pasture and range forages as the primary feed source with only minor requirements for supplemental minerals or protein. Depending on the particular circumstances, the grasses may be supplemented by harvested forages (especially for winter feedings) and larger volumes of feeds furnishing concentrated quantities of protein.

The extreme, on the other side, is to produce as much as possible through the feeding of grains. Only a minimum quantity of roughages, either as harvested or grazed forages, is used in this process.

Between these two extremes are a number of alternatives. The quantities of feed grains, protein supplements, harvested forages, and grazed forages vary with the age and sex of the animals as they are shifted from one diet to another.

While all of the production processes are limited by the nutritional requirements of the animal, the critical factor in determining the mix of feed used is the price of the possible feed combinations. For example, the relatively cheap ("free") range grass of the Western States during the 1800's and early 1900's made the grazing process the dominant means of both beef and lamb production. The development of cheap feed grains, especially during the 1950's and 1960's, resulted in a radical shift to the use of large quantities of those grains. Together with the expansion of the use of feed grains, there occurred a consumer acceptance of and demand for, the type of beef produced when large quantities of feed grains are used in the production process.

In the early forties, feed grains amounted to only 14 percent of the total feed unit intake of beef cattle, but by 1970, this percentage had increased to 24 percent. During this time, the proportions of grains and forages in livestock rations followed their relative prices. The price of grains relative to the price of forage declined throughout most of the period, and there was increased use of grains as cattle feed. Grain-fed beef cattle accounted for 78 percent of the number of all beef cattle slaughtered in 1970, but only 45 percent in the early fifties. In the fifties and earlier, cattle often weighed 800 to 900 pounds and were 2 years old before they were fed grain.[6]

[6] Skold, Melvin D. Future meat production demands from rangelands. Presented at 27th Annual Meeting of Society for Range Management, Tucson, Ariz. 1974.

Another change affecting feed use occurred in the beef cattle industry during 1973–75. This was the shift from intensive grain feeding of cattle and calves to primarily forage feeding or with only small amounts of grain. Non-grain-fed steers and heifers in 1974 accounted for 16 percent of the total slaughtered, compared with 3 percent in 1973 and 9 percent in 1971. Limited supplies and high feed grain prices suggest a continuing shift away from grain-fed beef. Forage requirements increase greatly as animals are kept out of the feedlots or until they are heavier and older.

The United States may have a decade of great price instability that will have tremendous impacts on the nature of livestock production. The proportions of grains and oilseed relative to forage, including range, going into the production of meat products will tend to shift back and forth rather dramatically. However, it is expected that the cumulative effect will be higher forage use in beef and lamb production.

Energy shortages and prices.—Recent and substantial increases in fossil fuel prices have caused fundamental changes in agricultural production processes.

Beef production processes of the 1950's and 1960's were among the high users of energy. The use of feed grains in finishing cattle resulted in the high inputs of fossil fuel energy for beef production. The process of adjusting energy consumption and production in agriculture to the changed energy situation has begun. Increasing fossil fuel costs create a need for the substitution of low energy-using production activities in many crop and livestock-producing systems for those of high energy use. Increased development and utilization of range for livestock production reduces the national energy requirements for meat production.

Steers fed a formulated ration under confinement would require about 100 megacals of fossil fuel to produce a pound of gain, whereas the fossil fuel expenditure per pound of livestock weight gain on range is relatively small. Cattle ranches in the Southwest, for instance, used approximately 4 gallons of gasoline and 62 kilowatt hours of electricity to produce 100 pounds of beef on the hoof in 1972. Range cattle production from grazing compared to feeding a ration of 20 pounds of alfalfa hay per day requires half the fossil fuel and electrical energy. In 1969, livestock ranches in the United States spent 2.8 cents for fossil fuels per dollar of product sold. If harvested feed grains were substituted for grazing from ranges, they would cost more than twice as much in fossil fuels.[7]

Fertilizer is another element requiring large amounts of energy from fossil fuels. Fertilizer usage in range forage production is relatively small. Additional harvested forages and grains to supply livestock feed requirements would require more fertilizer to increase yields. Thus, higher fertilizer costs are another factor which will tend to increase demand for forest-range grazing.

Energy price increases and resultant higher costs for many products will result in changes in the cost of range improvement practices necessary for increasing range grazing. Revegetation and brush control practices will be affected. As a consequence, some of the lower energy-using range improvement practices will be substituted for the high energy-using practices.

Technological Changes

In addition to the factors discussed above, future demands for forest-range grazing will be influenced by changes in animal meat, meat substitutes and analogs, fiber, range and agronomic technologies. If adopted in any large measure by producers and manufacturers, new technologies could have a considerable impact upon resulting supplies of livestock products. For this analysis, however, the assumption was made that scientific advances would continue to affect demand much as they have in the past.

Outside the realm of livestock production, the technology of synthetics and substitutes could affect rather significantly the demand for red meat, and, consequently, forest-range forages. Although synthetics and substitutes will not cause major adjustment problems for agriculture in the near future, they probably will continue to replace portions of red meat and natural fibers that would otherwise be consumed.[8]

Demand for Feed Grains and Forages for Livestock

There are, of course, many other factors which will affect the demand for forest-range grazing. For example, between 1960 and 1968, beef production increased by 41 percent. Much of the increased beef production during the 1950's and 1960's was achieved by increasing the number of animals in feedlots and by raising the average slaughter weight per animal, primarily through feeding of grain. A third significant factor in increasing beef production, without increasing forage production, was the replacement of dairy cows and dairy products with beef production.

The feedlot production and dairy production conversion will not be enough to get the necessary fu-

[7] Heady, Harold F., et al. Livestock grazing on Federal lands in the eleven Western States. Report of a task force of the Council for Agricultural Science and Technology. Range Manage. 27:175–181. 1974.

[8] Gallimore, William W., op. cit.

ture increases in beef production. Future beef production will require additional numbers of beef cattle.[9] This future reliance on increased numbers of cattle is an important factor in the estimated future demand for range grazing.

Feed grains.—Given the overall assessment of demand for beef and lamb, the higher costs of feed grains, and prospective technology, it is likely that most of the increased use of forages, and particularly the increases in forest-range grazing that have taken place in recent years, will be permanent. The proportion of total feeds supplied by feed grains will revert to a lower level.

This analysis assumes a high forage ration with only 20 percent of the total beef production produced from feed grains, compared to the 35 percent that could be supplied under 1950–1972 production processes.

The relative increase in the use of forage will not be reversed from the changes which occurred in the 1973–75 period, although the rate of change may be reduced in the next few years.

Forage.—The demand for range grazing is a part of the total demand for forage, including both harvested forage and grazed forage. The demand for forages is determined both by the price of the forages relative to feed grains and by the nutritional needs of the cattle.

The demand for grazing is also a function of time and location. Time is significant since forage of adequate quality is available for grazing only part of the year. Location is also significant since grazing must occur where the forage exists, while harvested forages can be transported to the livestock. These factors are also interrelated. For example, in the northern United States, the cold and snow frequently preclude grazing during many months and roughage must be supplied from "stored" harvested forage. Transportation cost is also an element to be considered. Harvested forages are expensive to transport and transportation of livestock is also costly. Thus, the demand for grazing is influenced by its availability relative to the availability of harvested forages and feed grains. Because forage is primarily a function of natural growth processes, its production is relatively inexpensive and, therefore, it is a low-cost feed source.

The environmental needs of cattle and sheep which can be met by pasture and range also tend to create a higher relative demand for grazing. Range grazing provides livestock with necessary space as compared with feedlot confinement which tends to increase the problems and losses associated with general health and disease.

[9] Van Arsdall, Roy N., and Melvin D. Skold. Cattle raising in the United States. U.S. Department of Agriculture, Econ. Res. Serv., Marketing Res. Rep. 947. 1973.

Range grazing.—Obviously, future changes in the basic determinants of demand for range grazing can vary widely. In recognition of this uncertainty, three levels of demand have been projected (table 43).

Projected demand under the medium level assumptions increases fairly rapidly in the next few decades reaching 320 million animal unit months in 2000, some 50 percent above the level attained in 1970 (table 43). There is some further growth beyond 2000 to 350 million months in 2000. The alternative assumptions on the factors affecting demand have important effects on projection levels and especially in the decades beyond 2000.

The projected increases in demand for range grazing will affect all range regardless of ownership. However, the increased demand is not likely to increase at the same rate in every range grazing or potential range grazing area. During the next few years, the increased demand will be most noticeable in the traditional range grazing areas of the West, in the Great Plains, and Western Range ecosystems. It will be equally noticeable in the southern areas where the beef cow herd has been increasing most significantly. These areas have major portions of the existing beef cattle industry and, therefore, the initial opportunity to respond to increasing demands through the increased utilization of the range.

As the areas with the most economical and convenient capability to increase range grazing respond to the increasing demand, their production costs will increase. Thus, in subsequent years, the pressure from increased demand for range grazing will move to additional areas.

The demand for range grazing also applies equally to all range regardless of ownership. The response to the demand for grazing will vary between all private range and public land range, however, because of geographic location. Western range, including the public lands in the West, will feel early pressure for increased use of range.

Table 43. *Projected demand for forest-range grazing in the United States, 1970–2020*

(*Millions of animal unit months*)

Year	Demand Level		
	Low	Medium	High
1970	213	213	213
1980	234	249	320
1990	240	285	380
2000	245	320	441
2010	245	334	475
2020	245	350	510

The Range Resource

The amount of range grazing actually supplied will depend on the area, productivity, and management of the Nation's forest-range resource.

The Nation's Range Base

About 1,556 million acres in the United States are classified as rangelands and commercial and noncommercial forest lands that are supplying, or have the potential to supply, forage for livestock and game animals. These lands comprise the "forest-range" earlier defined in this section. This is 69 percent of the total land area of 2,268 million acres.

The 48 contiguous States.—The 48 contiguous States have an estimated 1,202 million acres of forest-range, 63 percent of the total land surface of those States (table 44). Seventy percent, or 836 million acres, of the forest-range area is in the 17 western States (fig. 25). The rest, 366 million acres, is in the Northeast and Southeast and is essentially all forest land.

Every State has a significant amount of forest-range (fig. 26). Texas, with 113 million acres, has more than any other State. The 11 far Western States collectively, however, have 622 million acres, more than half of the total in the 48 States. This is about 83 percent of the land surface area of these 11 Western States.

F-435003

Many of the Nation's commercial timber types—such as this ponderosa pine type—are also producers of forage for livestock and wildlife.

In 35 States, more than half the land area is classed as forest-range and in 4—Nevada, New Mexico, Maine, and Wyoming—the proportions are 90 percent or more. Even such highly industrialized and heavily populated States as Pennsylvania, Massachusetts, and Rhode Island have more than half their land surface classified as forest with a potential to produce forage. Delaware has the least forest-range—only 397,000 acres. Nevertheless, this represents almost one-third of its land area. The crop-oriented Cornbelt States of Iowa, Illinois, Indiana, and Ohio have the lowest proportions of their land areas in forest-range, but together they have over 16.6 million acres—largely forest land. Most of the true prairie grasslands and much of the forest lands originally present in these 4 States have been converted to croplands and are not now considered as range.

The history of range in the Plains States is similar to that of the Cornbelt States. However, some 214 million acres, or 52 percent of these States, are still in rangeland and forest land.

Alaska and Hawaii.—Alaska has 351 million acres of forest-range, 97 percent of its total land area. Hawaii has only 3 million acres, but this is 70 percent of its land area. In both States, most of the forest-range is not now being used by livestock.

Resource Outputs

The Nation's 1.6 billion acres of forest-range yield many resource outputs which are as variable as the range is variable. From a range management standpoint, the primary output is forage, i.e., the herbaceous and woody vegetation available and suitable as food for livestock and game animals. Less commonly recognized are output values such as wildlife habitat, water, and wood, and such qualitative values as natural beauty, cultural heritage, and rare species.

Forage production.—A principal direct economic output of forest-range lands is livestock forage. Forage production is commonly measured in terms of animal unit months (AUM's). One AUM is the amount of grazing required by a mature cow for 1 month. In 1970, the Nation's ranges provided enough grazing for more than 213 million AUM's (table 45). Most of this grazing, 183 million AUM's or 86 percent, was produced on non-Federal lands, while 5 percent was produced on National Forest System lands, and the remaining 9 percent on all other Federal lands.

Table 44. *Area of forest-range in the United States, 1970*

(*Thousand acres*)

Region and State	Total land area	Forest-range	
		Area	Percent of total land area
Alaska[1]	362,516	351,200	97
Hawaii[1]	4,106	2,880	70
48 contiguous States			
Western:			
Arizona	72,688	63,204	87
California	100,207	66,694	67
Colorado	66,486	51,003	77
Idaho	52,933	42,317	80
Montana	93,271	75,464	81
Nevada	70,264	63,969	91
New Mexico	77,766	71,448	92
Oregon	61,599	53,623	87
Utah	52,697	45,181	86
Washington	42,694	31,401	74
Wyoming	62,343	57,367	92
Total	752,948	621,671	83
Plains:			
Kansas	52,511	15,701	30
Nebraska	49,032	24,958	51
North Dakota	44,032	12,543	28
Oklahoma	44,088	22,044	50
South Dakota	48,882	25,895	53
Texas	168,218	112,711	67
Total	406,763	213,852	53
Northeast:			
Connecticut	3,135	1,992	64
Delaware	1,266	397	31
District of Columbia	39	0	0
Illinois	35,795	3,807	11
Indiana	23,158	3,902	17
Iowa	35,860	2,493	7
Kentucky	25,512	11,776	46
Northeast—con'd:			
Maine	19,848	17,844	90
Maryland	6,319	2,978	447
Massachusetts	5,035	3,289	65
Michigan	36,492	19,478	53
Minnesota	51,206	19,513	38
Missouri	44,248	14,979	34
New Hampshire	5,769	5,155	89
New Jersey	4,813	2,247	47
New York	30,681	17,188	56
Ohio	26,222	6,433	24
Pennsylvania	28,804	17,062	59
Rhode Island	677	431	64
Vermont	5,937	4,370	74
West Virginia	15,411	11,480	74
Wisconsin	35,011	15,178	43
Total	441,238	181,992	41
Southeast:			
Alabama	32,672	21,755	67
Arkansas	33,599	18,743	56
Florida	34,721	19,534	56
Georgia	37,295	27,491	74
Louisiana	28,868	15,824	55
Mississippi	30,223	16,995	56
North Carolina	31,403	20,716	66
South Carolina	19,374	12,582	65
Tennessee	26,728	13,831	52
Virginia	25,496	16,615	65
Total	300,379	184,086	61
48-State total	1,901,328	1,201,601	63
50-State total	2,267,950	1,555,681	69

[1] Data for Alaska and Hawaii are for 1974.

Sources: Land base—U.S. Department of the Interior, Public Land Statistics, 1969 and 1972; Forest-range—48 contiguous States—U.S. Department of Agriculture, Forest Service. *The Nation's range resources—a forest-range environmental study*. Forest Resource Report 1972; U.S. Department of Agriculture, *National inventory of soil and water conservation needs*, 1967; U.S. Department of the Interior, Bureau of Land Management, Bureau of Indian Affairs, Bureau of Sport Fisheries and Wildlife, National Park Service.

The nonforested ecosystems in the Great Plains and Western Range ecogroups produced almost 149 million AUM's, 70 percent of the range grazing produced in the contiguous 48 States. The Eastern Forests ecogroup produced 53.5 million AUM's, 25 percent of the total production. Although the Western Forests made up 13 percent of the land area occupied by forest-range, they contributed only 10.7 million AUM's, about 5 percent of the total.

In terms of food for livestock, the plains grasslands and the prairie are the most productive ecosystems. They produced over 41 percent of the total AUM's although they occupy only 18 percent of the total range area. Other major contributors to AUM production are the mountain grasslands and sagebrush in the Western Range ecogroup and the oak-hickory and longleaf-slash pine ecosystems in the Eastern Forests.

On National Forest System lands, the two largest producers of grazing are the mountain grasslands and the mountain meadow ecosystems, which together produced over 3.2 million AUM's in 1970, over 25 percent of the production on ranges administered by the Forest Service. Other important pro-

GEOGRAPHIC DISTRIBUTION OF FOREST-RANGE

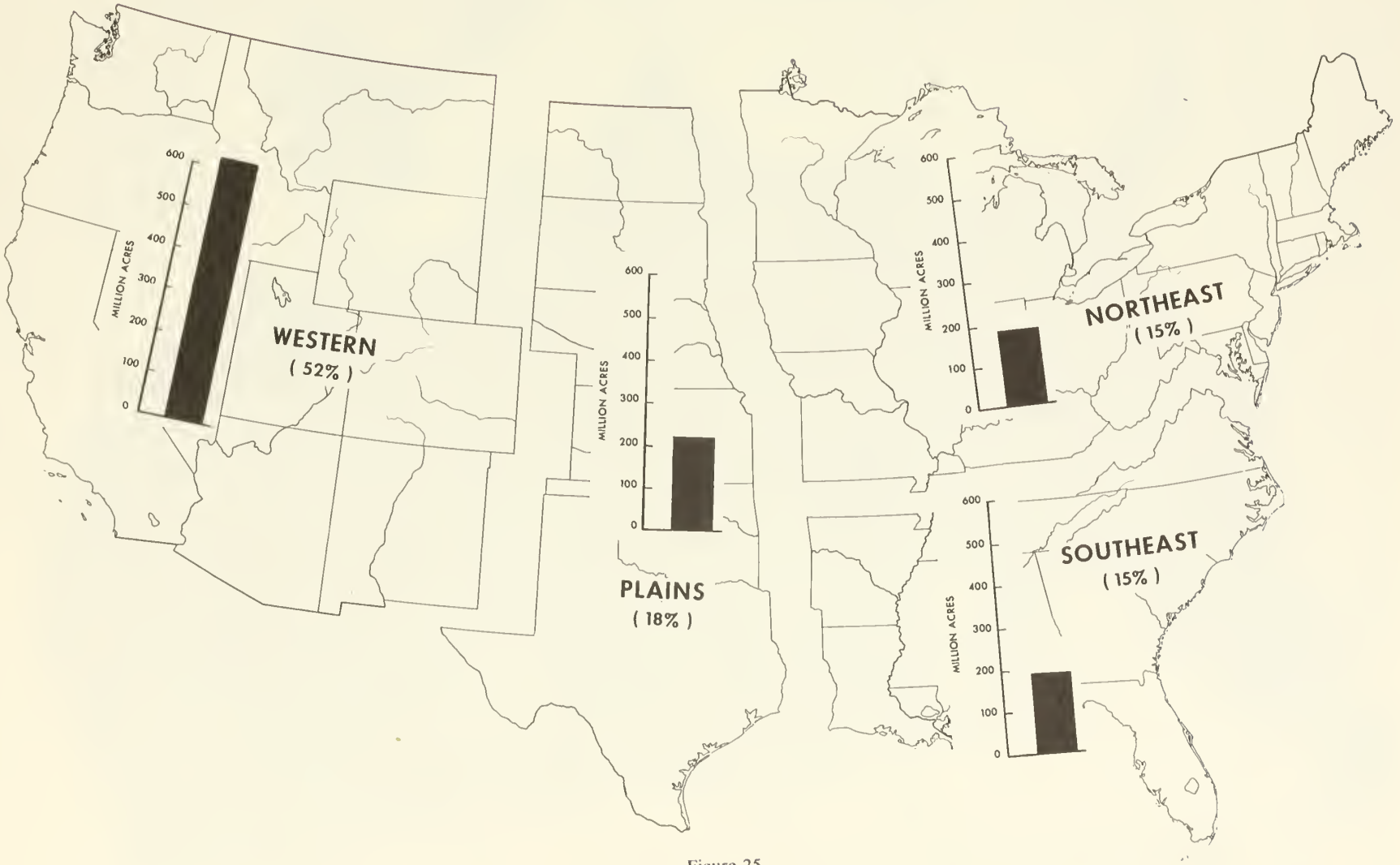
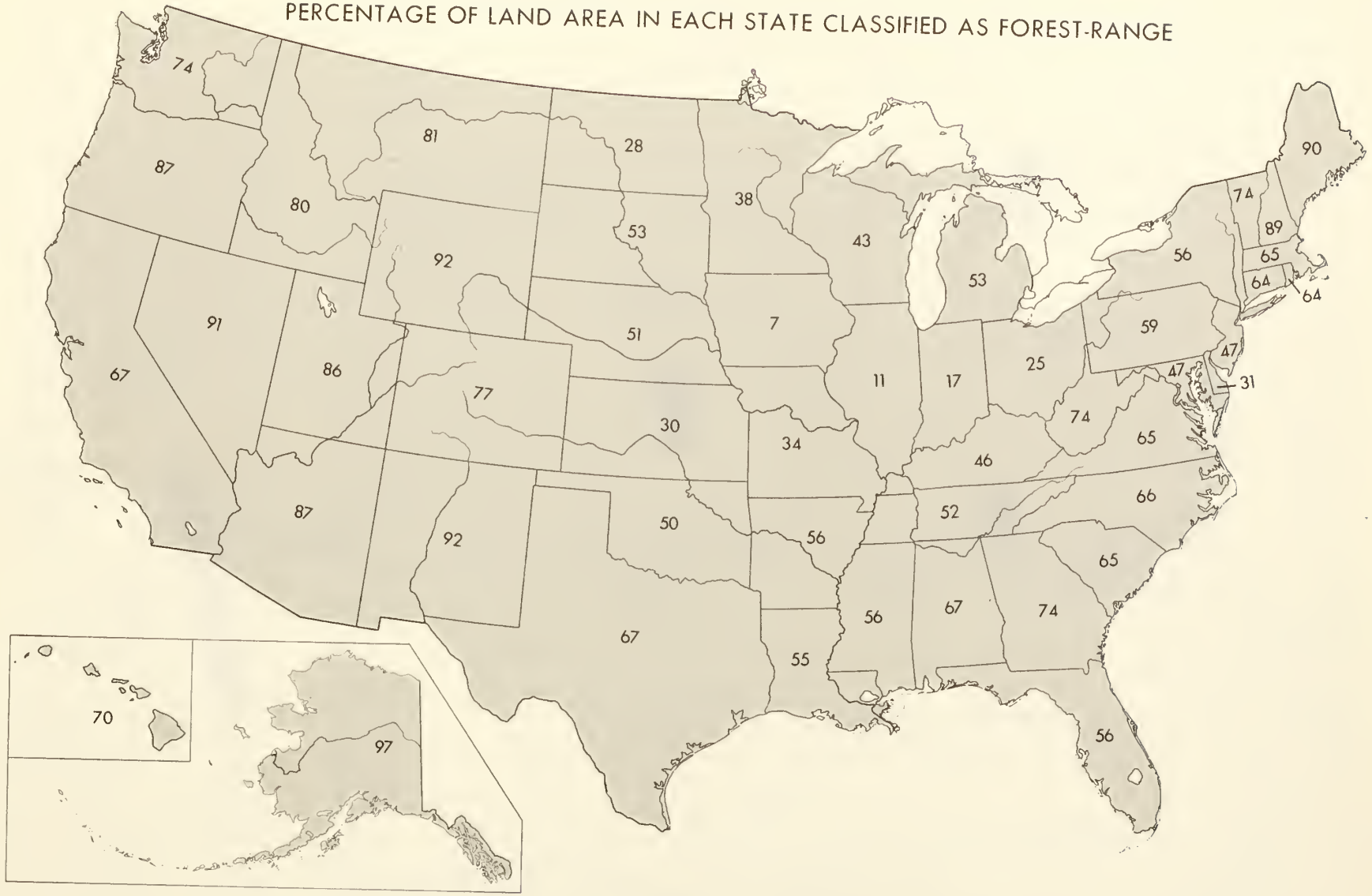


Figure 25


PERCENTAGE OF LAND AREA IN EACH STATE CLASSIFIED AS FOREST-RANGE
74
87
81
28
38
90
74
89
80
53
43
56
65
92
53
64
64
91
51
7
59
47
67
86
11
17
25
47
31
77
30
34
74
65
46
87
92
50
56
52
66
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56
74
55
56
70
97

Figure 26

Table 45. *Production of forest-range grazing in the contiguous United States, by ownership and ecosystem, 1970*

(*Thousand animal unit months*)

Ecogroup by ecosystem	All ownerships	National Forest System	Other Federal land	Non-Federal land
Western Range:				
Sagebrush	10,850	1,211	7,938	1,701
Desert shrub	1,742	13	1,433	296
Southwestern shrubsteppe	1,958	55	657	1,246
Chaparral-mountain shrub	1,957	378	647	932
Pinyon-juniper	1,715	558	498	659
Mountain grasslands	21,441	1,629	1,802	18,010
Mountain meadows	4,309	1,590	111	2,608
Desert grasslands	5,073	230	1,828	3,015
Annual grasslands	7,003	.....	635	6,367
Alpine[1]	33	32	1	.....
Total	56,081	5,696	15,551	34,834
Western Forests:				
Douglas-fir	623	423	32	168
Ponderosa pine	2,383	1,374	111	898
Western white pine	.....	.....	.....	.....
Fir-spruce	.....	.....	.....	.....
Hemlock-Sitka spruce	.....	.....	.....	.....
Larch	65	47	2	16
Lodgepole pine	74	59	1	13
Redwood	.....	.....	.....	.....
Hardwoods	7,584	1,431	449	5,705
Total	10,729	3,334	594	6,801
Great Plains:				
Shinnery	456	32	(2)	424
Texas savanna	5,042	.....	.....	5,042
Plains grasslands	50,454	967	2,423	47,064
Prairie	36,814	162	42	36,609
Total	92,767	1,161	2,465	89,140
Eastern Forests:				
White-red-jack pine	.....	.....	.....	.....
Spruce-fir	.....	.....	.....	.....
Longleaf-slash pine	11,218	400	15	10,803
Loblolly-shortleaf pine	6,686	344	7	6,335
Oak-pine	4,909	76	4	4,829
Oak-hickory	11,692	63	13	11,616
Oak-gum-cypress	750	2	2	746
Elm-ash-cottonwood	5,329	3	9	5,317
Maple-beech-birch	4,837	40	2	4,795
Aspen-birch	5,715	136	58	5,521
Wet grasslands	2,388	.....	36	2,352
Total	53,525	1,064	147	52,314
Grand total	213,102	11,255	18,757	183,090

[1] Includes barren areas above treeline.

[2] Less than 500 animal unit months.

Note: Columns may not add due to rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

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Plains grasslands are important sources of forage for domestic livestock. The variety of vegetation and landform in many areas also add beauty and diversity to the landscape and provide desirable habitat for many species of wildlife.

ducers are the western hardwoods, ponderosa pine, and sagebrush ecosystems.

The sagebrush ecosystem is by far the single most important producer on ranges administered by the other Federal agencies. The vast acreage of sagebrush under Bureau of Land Management administration alone produces most of a total of 8 million AUM's. Other significant ecosystems producing grazing on other Federal lands are the plains grasslands, desert grasslands, mountain grasslands, and desert shrub.

The two grass-dominated ecosystems in the Great Plains, plains grasslands and prairie, are the most important producers on non-Federal ranges. Combined, they contributed almost 84 million AUM's in 1970, 46 percent of all the range grazing produced on the non-Federal lands.

Average forage production.—Average forage production in 1970 for all the forest-range grazed by livestock was about 0.26 AUM's per acre (table 46). Thus, for the Nation, about 4 acres was required to sustain a mature cow for 1 month. Differences in relative productivity between ownerships depended to a large degree on the levels of management practiced on Federal and non-Federal lands, and the productivity and the ownerships of the ecosystems. In general, most of the highly productive ecosystems of the Great Plains ecogroup, the wet grasslands in the East, and the annual grasslands of the Western Range are in private rather than Federal ownership. In addition, a greater share of the private lands tends to be managed intensively and for maximizing livestock production than is the case with the Federal lands. In fact, constraints of law and policy preclude most opportunities for maximizing livestock production on Federal lands. As a result, AUM production averages vary from about 3 acres per AUM on private lands to 9 acres on Federal lands.

The wet grasslands ecosystem is the most produc-

Table 46. *Average forage production from forest-range in the contiguous United States, by ecosystem, 1970*

(*Animal unit months per acre per year*)

Ecosystem	1970 average	Ecosystem	1970 average
Western Range:		Great Plains:	
Sagebrush	0.12	Shinnery	0.23
Desert shrub	.03	Texas savanna	.34
Southwestern shrubsteppe	.06	Plains grasslands	.31
Chaparral-mountain shrub	.07	Prairie	1.01
Pinyon-juniper	.05		
Mountain grasslands	.29	Eastern Forests:	
Mountain meadows	1.14	White-red-jack pine	.....
Desert grasslands	.19	Spruce-fir	.....
Annual grasslands	1.05	Longleaf-slash pine	.77
Alpine[1]	.21	Loblolly-shortleaf pine	.22
		Oak-pine	.21
Western Forests:		Oak-hickory	.23
Douglas-fir	.04	Oak-gum-cypress	.08
Ponderosa pine	.07	Elm-ash-cottonwood	.36
Western white pine	.....	Maple-beech-birch	.62
Fir-spruce	.....	Aspen-birch	.99
Hemlock-Sitka spruce	.....	Wet grasslands	2.61
Larch	.01		
Lodgepole pine	.01	Weighted average	0.26
Redwood	.....		
Hardwoods	.33		

[1] Includes barren areas above treeline.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

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Large areas of rangeland in the arid and semiarid regions of the West have low inherent productivity for livestock forage.

tive, averaging 2.61 AUM's of forage per acre per year. Other high-producing ecosystems are mountain meadows (1.14 AUM's), annual grasslands (1.05 AUM's) and prairie (1.01 AUM's). The arid and semiarid ecosystems in the Western Range and some of the Western Forest ecosystems have quite low average AUM productivities, as low as 0.01 AUM per acre. Translated into stocking rates for livestock, 100 acres of the lodgepole pine and larch ecosystems would be required to provide enough forage to sustain a cow for 1 month. This contrasts sharply with the wet grasslands, where only 0.4 acre is needed to support a cow for 1 month.

Herbage and browse production.—The herbage and browse produced in the forest-range ecosystems is more than food for livestock, it is also food for wildlife. But equally important, it also provides the home or habitat for wildlife and ground cover protecting the soil resources.

The total production of herbage and browse on the forest-range is estimated to be in excess of 485 million tons annually (table 47). This represents an average production nationwide of over 800 pounds per acre. The largest share comes from the Great Plains ecogroup which produces 155 million tons. The Western Range produces 145 million tons, followed by the Eastern Forests with 133 million tons, and the Western Forests contribute 52 million tons.

The average production of herbage and browse in the two nonforested ecogroups is 927 pounds per acre, almost 40 percent higher than in the forested ones (table 48). The Great Plains has the highest average production, 1,354 pounds per acre. This high average production is the reason more herbage and browse are produced by this ecogroup than by any of the others, even though two other ecogroups exceed it in size.

Overall, the non-Federal lands produce about 200 more pounds of herbage and browse per acre than do the Federal lands. There are, however, some significant differences in production between ownerships in the various ecogroups, especially in the Eastern Forests. The high average of 1,948 pounds per acre in other Federal ownerships in this ecogroup is two to three times as high as that on the National Forest System and non-Federal lands. This reflects the high average production, over 2-1/2 tons per acre, of the wet grasslands ecosystem which makes up almost one-third of the other Federal holdings in the ecogroup.

Other outputs from forest-range.—As indicated, the forest-range provides resources other than forage and herbage. For example, the forest-rangelands contain the headwaters of all the Nation's major rivers. The forest-range also produces some 20.5 billion cubic feet of wood annually, with about 70 percent of the wood being grown in the Eastern Forests, 27 percent in the Western Forests, and 3 percent in

Table 47. *Herbage and browse production from forest-range in the contiguous United States, by ownership, ecogroup, and ecosystem, 1970*

(*Thousand tons per year*)

Ecogroup by ecosystem	All ownerships	National Forest System	Other Federal Land	Non-Federal land
Western Range:				
Sagebrush	35,840	4,209	26,931	4,700
Desert shrub	9,491	28	7,667	1,796
Southwestern shrubsteppe	3,526	119	1,345	2,061
Chaparral-mountain shrub	11,559	2,634	5,481	3,445
Pinyon-juniper	4,934	1,722	1,362	1,850
Mountain grasslands	60,858	7,239	5,275	48,343
Mountain meadows	5,482	2,794	219	2,470
Desert grasslands	6,481	358	2,479	3,643
Annual grasslands	6,886	.....	594	6,292
Alpine	97	88	9	.....
Total	145,154	19,192	51,362	74,600
Western Forests:				
Douglas-fir	16,335	7,394	1,439	7,502
Ponderosa pine	11,762	6,017	524	5,221
Western white pine	280	241	2	37
Fir-spruce	4,662	3,528	334	799
Hemlock-Sitka spruce	2,270	375	116	1,779
Larch	1,341	887	52	402
Lodgepole pine	2,763	2,038	274	451
Redwood	344	1	32	311
Hardwoods	12,304	2,578	674	9,052
Total	52,060	23,060	3,447	25,554
Great Plains:				
Shinnery	927	90	3	834
Texas savanna	8,352	5	77	8,270
Plains grasslands	91,408	2,475	5,437	83,496
Prairie	54,252	402	232	53,618
Total	154,938	2,971	5,749	146,218
Eastern Forests:				
White-red-jack pine	.....	.....	.....	.....
Spruce-fir	.....	.....	.....	.....
Longleaf-slash pine	12,272	756	497	11,019
Loblolly-shortleaf pine	8,038	592	110	7,336
Oak-pine	6,590	405	164	6,021
Oak-hickory	22,641	1,288	373	20,980
Oak-gum-cypress	1,940	17	131	1,792
Elm-ash-cottonwood	5,500	3	10	5,487
Maple-beech-birch	30,264	2,507	180	27,577
Aspen-birch	33,986	3,828	290	29,868
Wet grasslands	12,090	135	7,040	4,915
Total	133,320	9,530	8,794	114,996
Grand total	485,472	54,753	69,352	361,368

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

Table 48. *Average production of browse and herbage from forest-range in the contiguous United States, by ownership and ecogroup, 1970*

(*Pounds per acre*)

Ecogroup	All ownerships	National Forest System	Other Federal lands	Non-Federal lands
Nonforested				
Western Range	693	744	574	793
Great Plains	1,354	1,522	1,618	1,342
Average; nonforested	927	799	614	1,088
Forested				
Western Forests	648	530	582	828
Eastern Forests	678	817	[1]1,948	637
Average; forested	669	590	1,712	665
Average; all ecogroups	808	660	671	871

[1] Includes most of the wet grasslands, a highly productive ecosystem.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

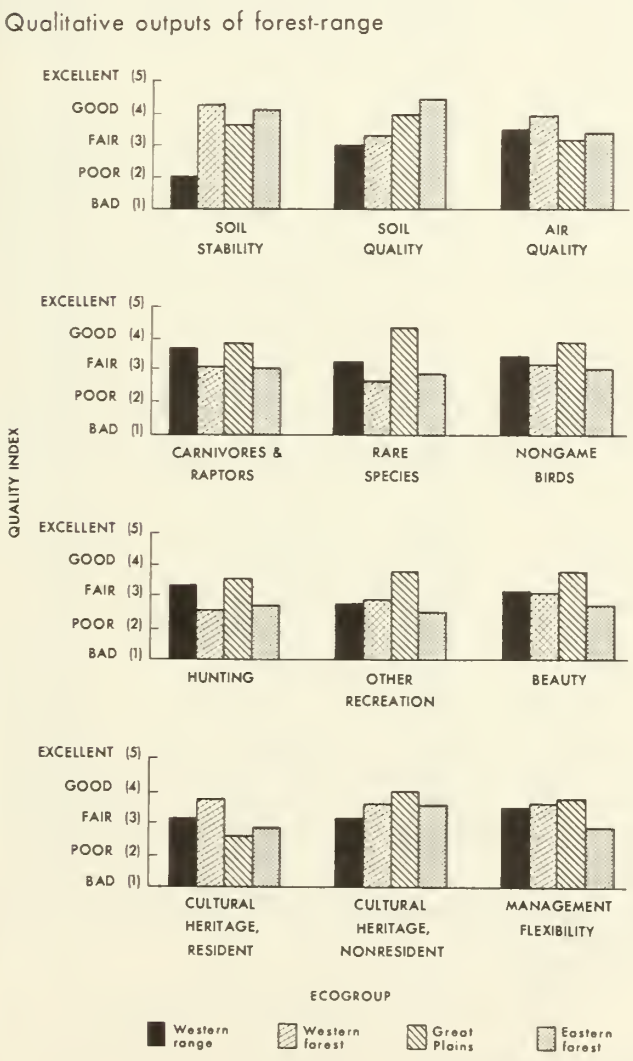

Figure 27

the pinyon-juniper ecosystems (table 49).[10] Annual water yield is estimated to be 781 million acre feet with 90 percent of the yield meeting high water quality standards. About 85 percent of the water came from the forested ecosystems, with the Eastern Forests producing more than the Western Forests. Yield of quality water is similar and sediment yields are low from the two forested areas—about half a ton per acre annually. Compared to the forests, the nonforested ecosystems yield much less water and five to six times as much sediment per acre.

Many of the other outputs from forest-range are difficult to evaluate in conventional quantitative terms. Such items have been rated in a qualitative way ranging from bad to excellent. These outputs, shown in figure 27, were rated generally fair to good for all ecogroups. A major exception is soil stability in the Western Range, which was rated as poor and accounts for the high sediment yield from this ecogroup.

Area Grazed

The 48 States.—Of the 1,202 million acres of forest-range in the contiguous States, 835 million acres or 69 percent were grazed by livestock in 1970 (table 50). More than 80 percent of the land grazed is in the 17 Western and Plains States. Each of these States has large amounts of forest-range and, with the exception of Washington, Oregon, and Oklahoma, 3 out of every 4 acres of their ranges are being used to produce livestock.

[10] These wood growth figures differ from those usually quoted for the United States. In addition to wood growth in commercial forests, these estimates include growth in noncommercial forest lands, wildernesses, National Parks, wildlife refuges, and other forested areas not normally considered in estimates of the timber resource.

Table 49. *Wood growth and average hydrologic outputs from forest-range in the contiguous United States, by ecosystem, 1970*

Ecogroup by ecosystem	Total net wood growth [1]	Water yield	Quality water	Storm runoff [2]	Sediment
	Million cubic feet per year	*Acre-feet per year*	*Acre-feet per year*	*Inches per acre*	*Tons per acre per year*
Western Range:					
Sagebrush	.....	0.18	0.18	0.09	5.41
Desert shrub	.....	.....	.....	.17	.40
Southwestern shrubsteppe	.....	.....	.....	1.07	.45
Chaparral-mountain shrub	.....	.11	.11	.84	7.86
Pinyon-juniper	607	.06	.06	.22	5.12
Mountain grasslands	.....	.62	.57	.23	1.37
Mountain meadows	.....	.82	.76	.11	.14
Desert grasslands	2	.....	.....	.37	.13
Annual grasslands	.....	.19	.19	.14	.54
Alpine	.....	2.70	2.70	.39	.....
Total	609	[3].24	[3].23	[3].32	[3]2.74
Western Forests:					
Douglas-fir	2,312	1.23	1.22	.90	.36
Ponderosa pine	987	.41	.32	.01	.20
Western white pine	31	.80	.80	.....	.....
Fir-spruce	564	2.06	2.06	.11	.....
Hemlock-Sitka spruce	652	4.14	4.14	1.68	.20
Larch	178	1.79	1.78	.08	.02
Lodgepole pine	240	.28	.27	.14	.07
Redwood	178	3.84	3.84	1.72	.37
Hardwoods	339	.52	.37	.72	2.49
Total	5,480	[3]1.10	[3]1.05	[3].44	[3].52
Great Plains:					
Shinnery	.....	.03	.03	.62	.45
Texas savanna	.....	.15	.10	2.60	.23
Plains grasslands	.....	.02	.....	.49	1.15
Prairie	.....	.32	.13	.99	1.40
Total	.....	[3].08	[3].03	[3].72	[3]1.12
Eastern Forests:					
White-red-jack pine	446	1.20	1.20	.10	.....
Spruce-fir	667	1.70	1.70	.60	.....
Longleaf-slash pine	854	1.56	1.51	3.41	.....
Loblolly-shortleaf pine	3,323	1.22	1.05	1.26	.33
Oak-pine	1,586	1.63	1.23	1.32	.77
Oak-hickory	4,054	1.11	.98	.78	.78
Oak-gum-cypress	1,555	1.30	1.21	4.80	.....
Elm-ash-cottonwood	590	.91	.78	.70	.97
Maple-beech-birch	932	1.40	1.28	.85	.10
Aspen-birch	362	.70	.70	.22	.....
Wet grasslands	.....	.87	.87	5.47	.....
Total	14,369	[3]1.24	[3]1.11	[3]1.37	[3]0.43
Grand total	20.459	[3]0.65	[3]0.59	[3]0.76	[3]1.38

[1] Includes growth in commercial and noncommercial forest lands, wildernesses, National Parks, wildlife refuges and other forested areas not commonly considered in estimates of commercial timber production.

[2] The amount of runoff expected for a 2-year 2-day storm for a given site.

[3] Weighted average.

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

Table 50. *Grazed and ungrazed forest-range in the contiguous United States, by State and ownership, 1970*

(Thousand acres)

States by geographic regions	All ownerships			National Forest System			Other Federal land			Non-Federal land		
	Total	Grazed	Ungrazed	Total	Grazed	Ungrazed	Total	Grazed	Ungrazed	Total	Grazed	Ungrazed
Western:												
Arizona	63,204	52,057	11,147	11,437	9,838	1,599	17,935	12,212	5,723	33,832	30,007	3,825
California	66,694	53,453	13,241	20,040	14,193	5,847	15,754	12,875	2,879	30,900	26,385	4,515
Colorado	51,003	41,427	9,576	14,334	8,904	5,430	9,136	7,391	1,745	27,533	25,132	2,401
Idaho	42,317	31,878	10,439	20,352	13,186	7,166	11,065	10,023	1,042	10,900	8,669	2,231
Montana	75,464	63,731	11,733	16,670	11,214	5,456	10,710	8,591	2,119	48,084	43,926	4,158
Nevada	63,969	56,656	7,313	5,074	3,464	1,610	51,864	46,541	5,323	7,031	6,651	380
New Mexico	71,448	64,738	6,710	9,186	8,113	1,073	17,183	15,440	1,743	45,079	41,185	3,894
Oregon	53,623	37,099	16,524	15,460	8,957	6,503	15,839	12,501	3,338	22,324	15,641	6,683
Utah	45,181	37,423	7,758	8,023	5,412	2,611	24,576	20,282	4,294	12,582	11,729	853
Washington	31,401	16,988	14,413	9,044	4,469	4,575	2,506	962	1,544	19,851	11,557	8,294
Wyoming	57,367	48,522	8,815	9,275	5,865	3,410	19,658	15,846	3,812	28,434	26,841	1,593
Total	621,671	504,002	117,669	138,895	93,615	45,280	196,226	162,664	33,562	286,550	247,723	38,827
Plains:												
Kansas	15,701	14,551	1,150	108	95	13	62	21	41	15,531	14,435	1,096
Nebraska	24,958	23,667	1,291	350	302	48	125	50	75	24,483	23,315	1,168
North Dakota	12,543	11,641	902	1,105	920	185	427	283	144	11,011	10,438	573
Oklahoma	22,044	15,544	6,500	288	195	93	329	122	207	21,427	15,227	6,200
South Dakota	25,895	24,485	1,410	1,983	1,832	151	577	486	91	23,335	22,167	1,168
Texas	112,711	95,218	17,493	776	669	107	1,422	878	544	110,513	93,671	16,842
Total	213,852	185,106	28,746	4,610	4,013	597	2,942	1,840	1,102	206,300	179,253	27,047
Northeast:												
Connecticut	1,992	1,147	845	.....	.....	.....	1	.....	1	1,991	1,147	844
Delaware	397	100	297	.....	.....	.....	6	.....	6	391	100	291
Illinois	3,807	2,288	1,519	237	.....	237	58	.....	58	3,512	2,288	1,244
Indiana	3,902	2,288	1,614	149	.....	149	81	.....	81	3,672	2,288	1,384
Iowa	2,493	1,628	865	.....	.....	.....	38	.....	38	2,455	1,628	827
Kentucky	11,776	3,194	8,582	548	.....	548	271	5	266	10,957	3,189	7,768
Maine	17,844	1,517	16,327	50	.....	50	60	.....	69	17,725	1,517	16,208
Maryland	2,978	1,433	1,545	.....	.....	.....	71	.....	71	2,907	1,433	1,474
Massachusetts	3,289	1,284	2,005	.....	.....	.....	40	.....	40	3,249	1,284	1,965
Michigan	19,478	5,218	14,260	2,666	50	2,616	77	7	70	16,735	5,161	11,574
Minnesota	19,513	4,631	14,882	2,780	56	2,724	234	13	221	16,499	4,562	11,937
Missouri	14,979	6,612	8,367	1,416	33	1,383	62	5	57	13,501	6,574	6,927
New Hampshire	5,155	754	4,401	680	.....	680	16	.....	16	4,459	754	3,705
New Jersey	2,247	921	1,326	.....	.....	.....	72	.....	72	2,175	921	1,254
New York	17,188	4,670	12,518	14	14	.....	108	.....	108	17,066	4,656	12,410
Ohio	6,433	3,450	2,983	132	1	131	38	.....	38	6,263	3,449	2,814
Pennsylvania	17,062	7,725	9,337	494	.....	494	46	1	45	16,552	7,724	8,798
Rhode Island	431	258	173	.....	.....	.....	.....	.....	.....	431	258	173
Vermont	4,370	616	3,754	239	9	230	12	.....	12	4,119	607	3,512
West Virginia	11,480	6,252	5,228	937	3	934	34	.....	34	10,509	6,249	4,260
Wisconsin	15,178	5,546	9,632	1,486	33	1,453	235	23	212	13,457	5,490	7,967
Total	181,992	61,532	120,460	11,828	199	11,629	1,569	54	1,515	168,595	61,279	107,316
Southeast:												
Alabama	21,755	12,351	9,404	631	261	370	199	7	192	20,925	12,083	8,842
Arkansas	18,743	8,885	9,858	2,449	1,202	1,247	416	31	385	15,878	7,652	8,226
Florida	19,534	8,758	10,776	1,080	224	856	1,918	20	1,898	16,536	8,514	8,022
Georgia	27,491	14,376	13,115	813	17	796	992	7	985	25,680	14,352	11,334
Louisiana	15,824	9,126	6,698	593	372	221	286	9	277	14,945	8,745	6,200
Mississippi	16,995	7,961	9,034	1,135	503	632	245	12	233	15,615	7,446	8,169
North Carolina	20,716	8,125	12,591	1,128	12	1,116	622	16	606	18,966	8,097	10,869
South Carolina	12,582	5,004	7,578	591	27	564	356	3	353	11,635	4,974	6,661
Tennessee	13,831	4,216	9,615	608	8	600	528	9	519	12,695	4,199	8,496
Virginia	16,615	5,561	11,054	1,512	18	1,494	510	10	500	14,593	5,533	9,060
Total	184,086	84,363	99,723	10,540	2,644	7,896	6,072	124	5,948	167,474	81,595	85,879
48-State total	1,201,601	835,003	366,598	165,873	100,471	65,402	206,809	164,682	42,127	828,919	569,850	259,069

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

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Over half of the forest land in the Southeast is grazed by domestic livestock.

Table 51. *Percent of forest-range grazed in the contiguous United States, by ecogroup and ownership, 1970*

Ownership	Total forest-range	Ecogroup			
		Western Range	Western Forests	Great Plains	Eastern Forests
National Forest System	61	71	65	87	15
Other Federal	80	86	34	82	2
Non-Federal	69	90	59	95	43
All ownerships	69	86	61	95	41

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

Only about one-third of the forst land in the Northeastern States is being used by livestock. Some of these States, however, do have a surprisingly high amount of grazing. For example, Illinois, Indiana, and Connecticut, all highly populated and industrialized, have 60, 59, and 58 percent, respectively, of their forests being grazed. Georgia, Alabama, and Louisiana are the big forest grazing States in the Southeast, both in terms of acres grazed and in terms of proportions of their forest lands being grazed—over 50 percent being used this way.

Percentage of forest-range grazed varies by ownership. In 1970, about 61 percent of the forest-range administered by the Forest Service was grazed, 80 percent of that administered by other Federal agencies and 69 percent in State and private ownership (table 51). Ninety-three percent of the grazed lands managed by the Forest Service and 99 percent of the grazed range managed by other Federal agencies are in the 11 Western States. The concentration of Federal grazing in the West is linked to the large areas of public lands that are dominated by grass and shrub ecosystems and the traditional use patterns of these ecosystems.

In contrast to the West, only 10 percent of all Federal lands in the East are grazed—most of this on National Forest System lands. Most of the other Federal lands are managed by the National Park Service or military agencies, which do not permit much livestock use on their lands.

Alaska and Hawaii.—Only 19 million of the 351 million acres of forest-range in Alaska are grazed by livestock, including reindeer (table 52). This represents only 6 percent of Alaska's forest-range. Over 80 percent of the area grazed is on Federal lands administered by the Bureau of Land Management and less than 1 percent on State and private lands. The balance is on lands administered by other Federal agencies. No National Forest System lands in Alaska are now grazed by livestock under permit.

Table 52. *Area of forest-range in Alaska and Hawaii, grazed and ungrazed, by ownership, 1974*

(*Thousand acres*)

State and ownership	Total	Grazed	Ungrazed
Alaska:			
National Forest System	16,861	0	16,861
National Resource Lands[1]	271,965	15,928	256,037
Other Federal	50,404	3,238	47,166
Non-Federal	11,970	187	11,783
Total	351,200	19,353	331,847
Hawaii:			
National Forest System	0	0	0
National Resource Lands[1]	0	0	0
Other Federal	272	1	271
Non-Federal	2,608	1,170	1,438
Total	2,880	1,171	1,709

[1] Public land administered by the Bureau of Land Management, Department of the Interior.

Almost all the forest-range lands grazed in Hawaii are in non-Federal ownership. Out of 1.2 million acres grazed, only 1,000 acres are Federal land. The Federal lands in Hawaii are primarily National Parks or military installations not ordinarily open to grazing by domestic livestock. Almost all of the livestock grazed are cattle.

Current Management

Livestock grazing operations vary across the country, area by area, ecosystem by ecosystem, and ownership by ownership. Climate, productive capabilities of the ecosystem, markets, goals of the operation—even tradition—all affect the kinds of operations and levels of management practiced.

To facilitate discussion, both in this and other sections of the report, the almost infinite number of management combinations have been classified into six broad management levels. They are:

1. *Environmental management without livestock.* (No livestock.) Goal is to eliminate commercial livestock grazing from the environment. Livestock are excluded physically by fencing, riding, or herding, and administratively by law, regulation, policy, or administrative decision.

2. *Environmental management with livestock.* (Some livestock.) Goal is to attain control of livestock numbers with little or no attempt to achieve uniform distribution of livestock. Livestock use is within the present apparent capacity of the range. Improvements and other investments are minimal and applied only to the extent needed to maintain stewardship of the range environment in the presence of grazing.

3. *Extensive management of the range environment and livestock.* (Extensive management.) Goal is to maintain full plant vigor and to achieve uniform and full livestock use of the available forage through construction of water developments and fences and the implementation of improved grazing systems. Maximizing of forage production by cultural practices and type conversion is not practiced.

4. *Intensive management of range environment and livestock.* (Intensive management.) Goal is to maximize production and utilization of livestock forage consistent with maintaining the environment and providing for multiple use of the range. Construction of improvements, control of undesirable plant species, and implementation of sophisticated grazing and livestock management systems are used as needed to achieve this goal.

5. *Environmental management with livestock production maximized.* (Maximize livestock.) Goal is to maximize production of livestock, but maintenance of the soil and water resources is required. Existing vegetation types, e.g., forest or shrub, may be replaced by higher producing forage. This level may require heavy investment in construction of range improvements, cultural practices, and animal husbandry. Multiple use of the range is not a constraint.

6. *Exploitative grazing.* Goal is to maximize livestock production in the short term. Stewardship of soil and water resources and consideration of multiple uses of the range are not required.

Maintenance of soil and water resources is required in all except management level 6, exploitative grazing. In levels 2, 3, and 4, multiple use requirements also constrain the intensity of grazing and the amounts and kinds of developments permitted. Exploitative grazing, though practiced on many ranges, cannot be considered as a desirable national objective. The sacrifice of soil and water resources in the interest of meeting short-term objectives is detrimental to the Nation's welfare in the longrun.

Management in the 48 States.—The management level on grazed lands in the United States varies considerably. Considering the forest-range in total, about 641 million acres out of the 835 million grazed in 1970 were under "some livestock" and "extensive management" systems (levels 2 and 3), 58 million under intensive management, and 50 million acres under the "maximize livestock" system (level 5) (table 53). Nearly 86 million acres were being exploitatively grazed.

Three-fifths of the area where livestock grazing from range was maximized was in the Great Plains ecogroup, mostly in the prairie and plains grassland ecosystems. One-fifth was in the mountain grasslands of the Western Range ecogroups. The balance was distributed throughout various ecosystems in all ecogroups.

Table 53. *Management levels on forest-range in the contiguous United States, by ecogroup and ecosystem, 1970*

(*Thousand acres*)

Ecogroup by ecosystem	Total	No livestock 1	Some livestock 2	Extensive management 3	Intensive management 4	Maximize livestock 5	Exploit-ative 6
Western Range:							
Sagebrush	94,219	3,766	22,304	55,717	8,329	2,037	2,064
Desert shrub	86,043	27,281	36,175	16,657	3,467	.....	2,461
Southwestern shrubsteppe	38,601	3,219	20,210	11,795	1,315	392	1,668
Chaparral-mountain shrub	32,081	1,963	17,083	11,431	1,000	590	13
Pinyon-juniper	42,677	8,514	5,871	21,900	3,274	769	2,346
Mountain grasslands	79,839	4,633	10,840	46,201	7,503	10,053	607
Mountain meadows	4,045	260	1,024	2,091	155	503	11
Desert grasslands	26,098	.....	3,601	19,895	1,395	874	332
Annual grasslands	6,700	4	9	4,691	1,051	313	632
Alpine[1]	8,322	8,160	111	46	4	.....	.....
Total	418,625	57,800	117,232	190,428	27,497	15,531	10,138
Western Forests:							
Douglas-fir	38,935	24,941	9,814	3,999	23	.....	157
Ponderosa pine	37,568	2,090	15,975	17,562	262	.....	1,677
Western white pine	4,053	2,656	1,396	.....	.....	.....	.....
Fir-spruce	24,384	16,975	7,408	.....	.....	.....	.....
Hemlock-Sitka spruce	7,076	7,076	.....	.....	.....	.....	.....
Larch	5,144	400	3,853	890	.....	.....	.....
Lodgepole pine	19,143	7,922	9,200	2,020	.....	.....	.....
Redwood	928	928	.....	.....	.....	.....	.....
Hardwoods	23,398	415	4,571	15,858	840	1,312	401
Total	160,629	63,405	52,220	40,332	1,125	1,312	2,235
Great Plains:							
Shinnery	2,004	22	215	809	396	546	15
Texas savanna	15,221	351	654	6,040	5,163	2,151	862
Plains grasslands	173,260	9,551	20,601	123,075	10,114	9,890	27
Prairie	38,374	1,835	1,906	12,502	3,733	18,396	.....
Total	228,859	11,759	23,378	142,428	19,406	30,983	904
Eastern Forests:							
White-red-jack pine	12,556	12,390	.....	.....	.....	.....	166
Spruce-fir	23,595	23,392	.....	.....	.....	.....	203
Longleaf-slash pine	20,889	6,311	1,962	494	174	.....	11,945
Loblolly-shortleaf pine	55,095	24,814	13,855	2,647	.....	426	13,351
Oak-pine	34,464	10,716	9,002	1,282	.....	1,944	11,518
Oak-hickory	125,081	73,544	8,044	21,208	7,703	.....	14,578
Oak-gum-cypress	34,074	24,235	21	.....	.....	.....	9,817
Elm-ash-cottonwood	25,038	10,032	4,816	5,848	1,526	.....	2,815
Maple-beech-birch	35,633	27,856	3,569	57	.....	.....	4,151
Aspen-birch	22,564	16,780	1,986	128	1	.....	3,668
Wet grasslands	4,494	3,578	82	185	464	.....	185
Total	393,483	233,648	43,345	31,852	9,869	2,370	72,399
Grand total	1,201,596	366,612	236,175	405,039	57,898	50,196	85,676

[1] Includes barren areas above treeline.

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

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Overgrazing in some humid areas leads to rapid erosion and the loss of productivity of the land. Under proper management such land can produce large amounts of grass or timber—or both.

Exploitative grazing occurred on lands of all ownerships. This level of grazing management amounted to about 1 percent of grazed National Forest System ranges, 3 percent of other Federal, and 14 percent of the non-Federal lands (table 54). The highest proportion of forest-range managed exploitatively occurred on non-Federal lands in the Eastern Forests ecogroup where about 38 percent of the non-Federal forested range was managed exploitatively, producing about one-fifth of the total AUM's (tables 55 and 56).

Alaska and Hawaii.—All grazed forest-range in Alaska is considered to be managed under level 2, i.e., management with some livestock and minimal use of improvements (table 57). Only a relatively few animals are involved. It is estimated that in 1974 only 400 horses, 4,000 cattle, 13,000 sheep, and 30,000 reindeer grazed the forest-range in Alaska.

In 1974, some 201,000 cattle and fewer than 500 sheep grazed the forest-range in Hawaii. About 71 percent of the ranges grazed were managed at level 3, extensive management with livestock. Some 86,000 acres, or about 7 percent of the total area grazed, was being grazed exploitatively. This is a somewhat higher proportion than in the contiguous 48 States.

Opportunities for Range Development and Management

There are opportunities to increase the production of forage over nearly all of the Nation's forest-range, and this must be done if projected demands shown in figure 28 are met. The largest opportuni-

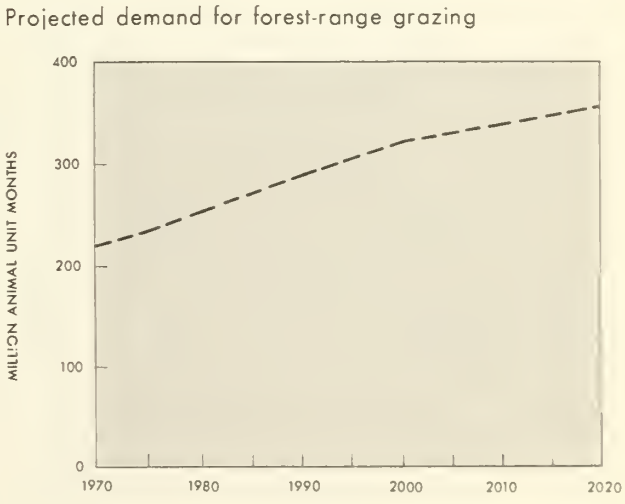


Figure 28

Table 54. *Management levels on forest-range in the contiguous United States, by ownership and ecogroup, 1970*

(*Thousand acres*)

Ownership by ecogroup	Total	No livestock 1	Some livestock 2	Extensive management 3	Intensive management 4	Maximize livestock 5	Exploit-ative 6
National Forest System:							
Eastern Forests	23,318	19,734	3,004	443	5	.....	129
Western Forests	87,066	30,135	35,864	20,718	327	.....	20
Western Range	51,588	15,009	16,596	16,524	2,576	.....	881
Great Plains	3,903	543	2,001	1,216	122	.....	19
Total	165,875	65,421	57,466	38,903	3,032	.....	1,051
All other Federal:							
Eastern Forests	9,030	8,690	156	54	2	.....	128
Western Forests	11,855	7,740	1,911	2,094	97	.....	13
Western Range	178,819	24,342	60,960	76,665	12,591	.....	4,260
Great Plains	7,105	1,355	2,494	3,102	145	.....	8
Total	206,809	42,127	65,521	81,915	12,836	.....	4,409
Non-Federal:							
Eastern Forests	361,135	205,224	40,184	31,355	9,861	2,370	72,141
Western Forests	61,708	25,529	14,444	17,519	700	1,312	2,202
Western Range	188,218	18,449	39,675	97,236	12,330	15,531	4,996
Great Plains	217,851	9,861	18,883	138,109	19,137	30,983	877
Total	828,912	259,063	113,186	284,220	42,029	50,196	80,216
All ownerships:							
Eastern Forests	393,483	233,648	43,344	31,852	9,868	2,370	72,398
Western Forests	160,629	63,404	52,220	40,331	1,125	1,312	2,235
Western Range	418,625	57,800	117,231	190,427	27,497	15,531	10,137
Great Plains	228,859	11,759	23,378	142,427	19,406	30,983	904
Total	1,201,596	366,611	236,174	405,039	57,897	50,196	85,676

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

Table 55. *Management levels on forest-range in the contiguous United States, by ownership, 1970*

(*Million acres*)

Ownership	Total	No live-stock 1	Some livestock 2	Extensive management 3	Intensive management 4	Maximize livestock 5	Exploit-ative 6
National Forest System	165.9	65.4	57.5	38.9	3.0	—	1.1
Non-Federal forested	422.8	230.8	54.6	48.9	10.6	3.7	74.3
All other	612.9	70.4	124.1	317.3	44.3	46.5	10.3
Total	1,201.6	366.6	236.2	405.1	57.9	50.2	85.7

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

Table 56. *Production of grazing on forest-range in the contiguous United States, by levels of management and ownership, 1970*

(Thousand animal unit months)

Ownership	Total	No livestock	Some livestock	Extensive management	Intensive management	Maximize livestock	Exploitative
		1	2	3	4	5	6
National Forest System	11,254.6	0.0	3,538.5	6,527.1	1,141.1	0.0	48.0
Non-Federal forested	59,115.5	0.0	13,572.2	13.046.9	7,848.1	6,931.5	17,716.8
All other	142,731.6	0.0	7,649.7	79,888.7	16,477.5	38,040.1	675.5
Total	213,101.7	0.0	24,760.4	99,462.7	25,466.7	44,971.6	18,440.3

Note: Columns may not add to totals because of rounding.

Source: *The Nation's range resources—a forest-range environmental study*, op. cit.

Table 57. *Management levels on forest-range in Alaska and Hawaii, by ownership, 1974*

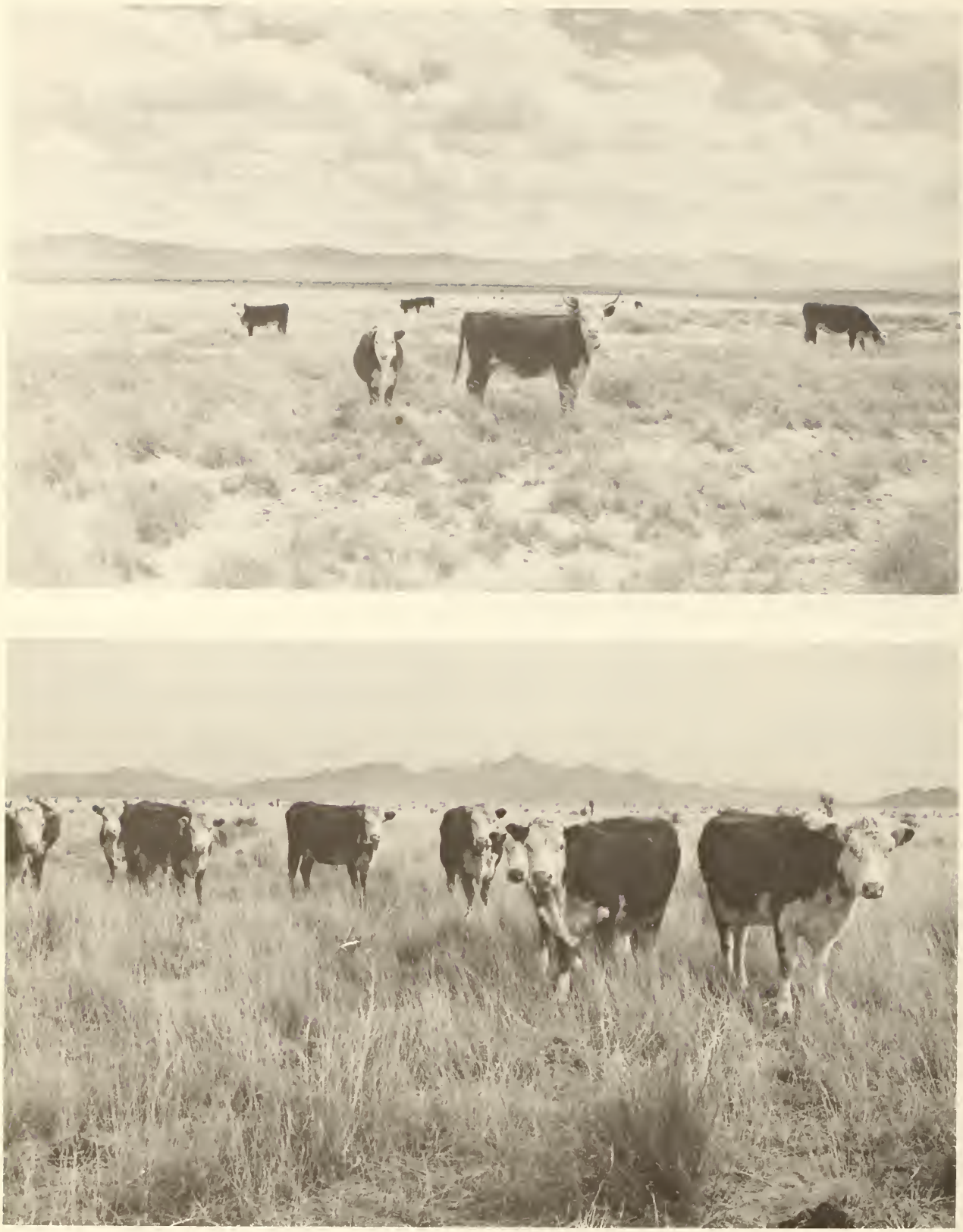
(Thousand acres)

State and land ownership	Total	No livestock	Some livestock	Extensive management	Intensive management	Maximize livestock	Exploit-ative
		1	2	3	4	5	6
Alaska:							
National Forest System	16,861	16,861	0	0	0	0	0
Other Federal	322,369	303,203	19,166	0	0	0	0
Non-Federal	11,970	11,783	187	0	0	0	0
Total	351,200	331,847	19,353	0	0	0	0
Hawaii:							
National Forest System	0	0	0	0	0	0	0
Other Federal	272	271	0	1	0	0	0
Non-Federal	2,608	1,438	10	833	212	29	86
Total	2,808	1,709	10	834	212	29	86

ties are on the lands in private ownership because they contain two-thirds of the forest-range area and support many of the most productive sites.

Federal lands make up slightly less than one-third of the forest-range area and produce less than 15 percent of the livestock animal unit months. However, their importance exceeds that apparent from area and AUM production. For the most part, livestock producers who graze livestock on the Federal lands depend on these lands to supply the seasonal forage needed to round out the yearlong operation of their farms and ranches. Without this complement of seasonal forage, many operators would have to reduce their livestock production to the limits dictated by the range resources they own or control. Such reductions could be substantial for many operators. Some would have to cease full-time ranch operations as they would no longer have viable economic units. The net result would be a reduction of livestock, not only on the Federal lands, but on the associated private lands as well.

In addition, the proximity and intermingling of lands dictates that sound range management plans include lands of both ownerships. Improved grazing systems installed on either Federal or private lands must consider the part that lands of each ownership play in the cycle of grazing. Through the direct effects upon the operations of grazing permittees and by demonstration of sound management, a range program directed at more meat from ranges can affect a large segment of the rural livestock economy throughout many areas of the United States. Thus, the influence of management on the public forest-range extends beyond the Federal land boundaries.



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The production of forage can be increased on nearly all of the Nation's forest-range including the lower productivity sites. Desert grasslands—poorly managed and properly managed.

Table 58. *Production of forest-range grazing and area grazed in the contiguous United States, with production potentials, by ownership, 1970*

Area and units	1970 actual	Production potentials		
		At least cost	Biologic	At economic limits
All forest-range:				
Grazing produced, million AUM's	213	213	566	350
Area grazed, million acres	835	372	1,161	895
National Forest System:				
Grazing produced, million AUM's	11	23	55	24
Area grazed, million acres	101	30	164	100
Non-Federal forested range:				
Grazing produced, million AUM's	59	83	316	147
Area grazed, million acres	192	54	385	230
All other:				
Grazing produced, million AUM's	143	117	195	179
Area grazed, million acres	542	288	612	565

Range Production Potential

The Nation's forest-range has the physical capability to produce the additional forage needed to meet projected future demands for livestock grazing. Increased production capacity can be achieved by adding facilities and improved management to the existing level of development. The dollar cost and the impact on the environment of increased production varies from one area to another and according to the intensity and purpose for which the range is managed.

Potential at least cost.—One way to estimate the production potential of forest-range nationally would be to estimate the production that would occur from the same amount of grazing that occurred in 1970, but to do that on a least-cost basis. Constraints would be added for soil and water protection, but no social constraints would be considered. In effect, grazing would shift to the places where forage could be produced at the lowest cost.

Under this option, the amount of forest-range to be grazed nationwide would be reduced from 835 million to 372 million acres and the total national cost of producing range grazing would be reduced by over half (table 58). These results are possible because of the relatively low efficiency in present development and management of the forest-range. High investments often are made on lands with low potential, while other lands with high potential are scarcely developed.

The National Forest System could produce 23 million animal unit months of grazing under this least-cost option. This represents a twofold increase in production over the 1970 level and requires using less than one-third of the area currently grazed. The non-Federal forested range would share significantly in the increased grazing under this option, increasing from 59 to 83 million AUM's. A sizeable reduction in acreage required to produce the increased amount of grazing, a reduction of about 138 million acres, would occur. Production on "other range" would drop from the 1970 level under the goal of least-cost achievement of AUM production. Animal unit months of grazing would decline from 143 million to 117 million and the area grazed from 542 to 288 million acres.

Under the least-cost option, animal unit months of grazing would be increased in the highly productive Eastern Forests ecosystems. Because fewer acres are grazed in this example, the total national output of

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The longleaf-slash pine ecosystem has the potential to produce large quantities of both forage and wood. Because of high productivity, this and other eastern forest-range ecosystems are the most cost effective places for initial investments in programs to increase forage production.

nonlivestock products of range would not be significantly changed. In the ecosystems carrying an increased grazing load, however, major changes in most other outputs (wood growth, for example) would occur.

This least-cost example is not a viable opportunity because institutional and social considerations preclude this kind of reallocation. It is, however, indicative of the direction in which capital and labor should flow to achieve initial gains in range grazing to meet future needs in the most effective manner. On the other hand, the example understates the high economic and social costs of actually making such a shift. Major shifts in grazing location would be necessary to achieve least-cost production.

Biologic potential.—The biologic potential production from forest-range is more than two and a half the 1970 level of 213 million animal unit months. That goal could be attained under an approach stressing intensive environmental and livestock management (level 4). Approximately 10 percent of the total production would come from the ranges of the National Forest System compared to the 5 percent of the grazing these lands produced in 1970. Fifty-six percent of the production would come from non-Federal forested ranges. The remaining 34 percent of the production would come from the 612 million acres of other range. The costs of attaining the biologic potential would be high. Total cost for range grazing would nearly double the present cost and would exceed the amount that could be recovered given expected price relationships.

Potential at economic limits.—When production of forest-range grazing is constrained by the limits of demands and costs, the potential production is limited to about 350 million animal unit months. While this is two-thirds the estimated biologic production under intensive management, it is about 64 percent higher than the 1970 production of 213 million AUM's.

Significantly, increasing grazing to the 350 million AUM level could be achieved nationwide by grazing only 7 percent more land than was grazed in 1970. Production of 24 million AUM's on the National Forest System would require grazing about the same amount of land that was grazed in 1970. This twofold increase in grazing with only a minor change in land required is possible because much range with considerable potential is waiting to be developed. An additional opportunity exists on non-Federal forested ranges to benefit other resources by eliminating exploitative grazing. The potential for a threefold increase in production on non-Federal forested ranges is closely associated with attaining suitable grazing management and the relatively high potential of those lands to produce forage at reasonable cost. The potential production on both National Forest System and non-Federal forested range is primarily achieved by varying the intensity of management in accordance with the productivity on each different site and in relation to cost.

The available data, which includes recognition of environmental and social concerns, indicate that cost of production increases rapidly after the 350 million animal unit months of production is achieved. Range grazing above that level would be unlikely given existing price relationships, alternative feed sources, and production costs. New technology would probably be necessary if range grazing is to exceed the 350 level, even in the year 2020.

Economic limits as used here are a "rough" measure of the equality of the value of the output versus the cost of production. As compared with the biologic potential, the economic limit is the maximum level of production that could be justified by the value of the outputs. The economic limit is primarily determined by an assessment of the changes in production cost rather than by comparing market value in relation to cost. However, it is intended that the economic limit would reflect that principle. As a least cost estimate, it is appropriate only to the inventory, productivity, cost data, and management practices as specified in the analysis. It is not a measure of the least cost source of livestock feed or least cost means of meat production.

The projections of demand (medium level) for forest-range grazing indicates increases of 17, 50, and 64 percent over the 1970 level for the years 1980, 2000, and 2020 (fig. 28). National Forest System range, non-Federal forested range, and other range could supply some portion of the increased demand depending on productive capabilities.

Increasing forest-range grazing by about 20 percent above the 1970 level would increase the cost per unit of grazing by about 1 percent. This initial increase from 213 million to 255 million animal unit months is very efficient. The second increment (an added 20 percent) increases grazing to nearly 300 million animal units months and cost per unit by 15 percent. Thus, a 40 percent increase in grazing could be achieved with a 16 percent increase in average cost of production per animal unit month. The increase to 300 million AUM's would require a 67 percent increase in total costs.

Management Opportunities

Substantial increases in forest-range grazing can be achieved in a variety of ways. However, benefits from most management practices will become available gradually, because much of the range responds slowly to development and management. More efficient management would involve some reallocation

of range use as management intensity is shifted to coincide with areas of expected high response. Increased output of non-livestock-forage values would require added inputs at additional cost.

Management.—Many proven and economically sound technologies and business practices are available that can be used in range management. Implementation of these technologies and practices would do much toward improving ranch income.

Selection of forage or feed sources in relation to animal physiological need is one way toward increased effectiveness. Use of forested ranges as forage sources for dry or nonlactating beef cows, while reserving improved pastures or other forage sources requiring high input of fertilizer or labor for maintenance for lactating cows and their calves, is another opportunity.

Extensive grazing occurred on many ranges in this country long before adequate information was available about how to manage them properly. In spite of changing emphasis on stewardship of the soil and water values, there are many opportunities to take corrective action and restore productivity to these lands.

Technical assistance.—Many of the livestock operations that use both range and pasture during the same season are privately owned. Application of range management, while good in many of these operations, could be improved through further educational efforts and technical assistance from agencies such as the Extension Service.

Technical assistance can be provided for planning, installing, and maintaining improved range management practices on non-Federal forested ranges. In the U.S. Department of Agriculture, the Soil Conservation Service offers such services in many areas within its conservation planning activities. Through its State and Private Forestry arm, the Forest Service provides technical assistance to owners of non-Federal forested ecosystems on forestry-related matters. A forest-range technical assistance program is not fully operational now. Grazing practices in forested ecosystems vary from exploitative to intensive well-managed grazing systems. Integrated timber-grazing management requires special practices and knowledge of the ecosystems.

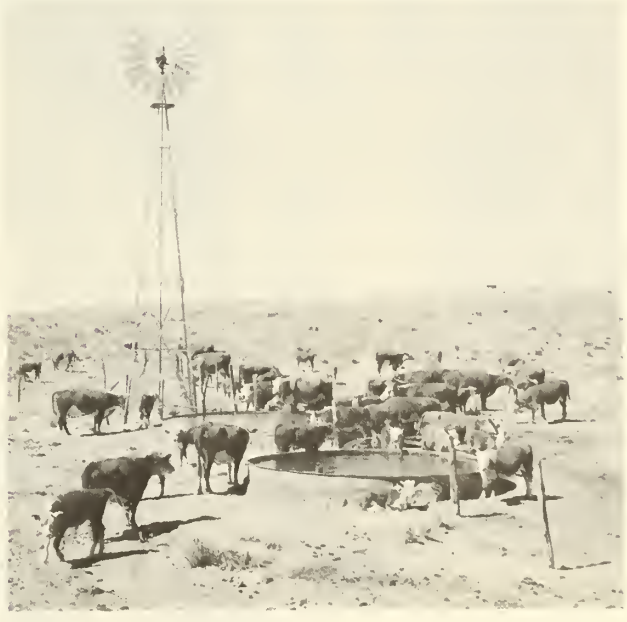
Opportunities exist to put available technology and skills to work toward development and implementation of better range grazing management systems. Systems could be developed and applied in accordance with the productive potential and development and management costs. They could also be designed to provide high-quality forage for livestock while maintaining and enhancing environmental resources and outputs.

Opportunities to demonstrate management systems exist in virtually all of the important forest-range ecosystems. Demonstration of range management systems on National Forests and non-Federal forested range could be an effective means of accomplishing the objective of better range management. A concentracted effort to identify, document, and publicize actual examples of success would accelerate the acceptance and installation of proven range management systems. At the same time, suggested methods and techniques of management and development could be tested and validated.

Cost-sharing.—Incentive or cost-share agreements are one way of getting necessary range management systems and land use adjustments installed. Development of a ranch or farm program requires major inputs from the owner. Incentive or cost-share programs can be used to accelerate the rate at which much needed land-use adjustments will be made.

Sharing costs of range development has been long used as a means of achieving range goals on the National Forest System. Joint investment of capital by the Federal government and the private operator who grazes his livestock on the Federal lands should continue. This will help meet Federal goals of proper resource use and the rancher's goal of sustained or enhanced income from his public land-based or private livestock operations.

Financing.—The range responds slowly to improvements in management practices. For example, the benefits from fencing or a water development



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Water development and fencing are two common practices necessary for grazing much of the western grass and shrub lands. These practices, in combination with seeding to better grasses or other forage species, can greatly increase the productivity of much of the Nation's range.

may not be apparent for 5 or more years after the improvements are made. The rancher who depends on borrowed capital to finance such improvements needs a loan system that is adjusted to the expected rate of return on the investment. Flexible repayment rates geared to slowly increasing and variable returns may be necessary.

Seeding ranges to better grasses or other forage species leads to higher production. However, seeding must be combined with other range practices such as water development and fencing to control livestock. These practices must be combined into a carefully managed system if they are to yield the expected benefits.

The amount of rangeland in poor ecological condition varies according to the kind of range, how long it has been grazed, ownership, and other factors, including the skill of the operator-manager. In total, in 1970 about 74.6 million acres of Eastern and Western Forests are being improperly managed for short-term livestock grazing at considerable expense to wood growth and soil and water values.

Wild horses.—Protection of wild and free-roaming horses and burros is required by the Wild Free-Roaming Horse and Burro Act (Public Law 92–195). The territories used by these animals must be identified and management plans prepared to ensure the availability of water and forage to meet the needs of these animals. Specific provisions for the protection of these animals from harassment and disturbance can be made.

Research.—Although much knowledge about the structure and functioning of range ecosystems has resulted from more than 60 years of research and management experience, managing livestock in an era of increasing complexities of interacting resource demands presents additional problems that need further study. Each ecosystem has its peculiar and specific needs.

Further research is needed on biological control of pests, economic guidelines, safer pesticides, and manipulation of vegetative cover in terms of livestock production, wildlife habitat, water yield, and soil erosion. Effective range inventory systems that can be meshed into multiresource inventory systems are also needed. Information is especially limited about the forest-range resource in Alaska and Hawaii.

Additional research is needed to breed plants that are adapted to specific range sites and better equipped to meet the broad range impacts on land use. Development of equipment for seeding these plants and methods of planting and managing them should coincide with their genetic development.

Timber

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Residential construction is the Nation's largest market for softwood lumber and plywood.

This chapter presents information on: (1) Recent trends in consumption of timber products and projections of demand to 2020; (2) international trade in timber products and the timber situation in the major trading countries; (3) recent changes in the area and condition of timber resources with projections of supplies to 2020; (4) comparisons of projected timber demands with supplies and the economic and social implications of prospective imbalances; and (5) opportunities for increasing and extending timber supplies.

Most of the material in this section has been condensed from the comprehensive report, "The Outlook for Timber in the United States"[1] published by the Forest Service in the fall of 1973. However, the demand projections from that study have been revised because of recent changes in expectations about growth in population, economic activity, income, and energy costs. Timber trade projections have also been slightly revised in line with recent changes in imports and exports. The data on the timber resource and supplies have not been adjusted, because it still presents a realistic appraisal of the present and prospective situation.

In the past few years, there have been a number of other reports and studies which are useful references on the timber situation and outlook and which supplement in various ways the Forest Service study. These include:

U.S. Senate, 91st Congress, 1st Session. Problems in lumber pricing and production. Hearings before the Subcommittee on Housing and Urban Affairs, Committee on Banking and Currency, March 19, 20, 21, 1968; 740 p.

U.S. House of Representatives, 91st Congress, 1st Session. Rising costs of housing: lumber price increases. Hearings before the Committee on Banking and Currency, March 24–28, 1969; 894 p.

U.S. Senate, 91st Congress, 1st Session. Effect of lumber prices and shortages on the Nation's housing goals. Report of the Subcommittee on Housing and Urban Affairs, Committee on Banking and Currency, June 16, 1969; 86 p.

Forest Service, U.S. Department of Agriculture. Possibilities for meeting future demands for softwood timber in the United States. Prepared for the Working Group of the Cabinet Task Force on Lumber, August 1969 (Rev. Sept. 1969); 24 p.

Southern Forest Resource Analysis Committee. The South's third forest—how it can meet future demands. Report of the Committee—1969; 117 p.

Task Force on Softwood Lumber and Plywood. Findings and recommendations. Press releases of memorandum to the Cabinet Committee on Economic Policy, and statement by the President, June 19, 1970; 8 p.

President's Advisory Panel on Timber and the Environment. Report of the Panel, April 1973; 541 p.

Cliff, Edward P. Timber : the renewable material. Prepared for the National Commission on Materials Policy, August 1973; 151 p.

Duerr, William A., editor. Timber: problems—prospects—policies. Iowa State University Press, 1973; 260 p.

Clawson, Marion, editor. Forest policy for the future—conflict, compromise, consensus. (Papers presented at the Forest Policy for the Future Forum, May 1974.) Resources for the Future, Inc., Johns Hopkins University Press, September 15, 1974; 360 p.

There are substantive differences among these reports in contents and objectives but the major conclusions about the timber outlook are in general agreement. For example, there was agreement that the Nation's demands for timber are likely to grow rapidly in the decades ahead.

The Demand for Timber

The initial demand projections (low, medium, and high) in this study have been developed under the assumption that the 1970 prices of timber products relative to average prices of all commodities and to most competing materials would not change significantly during the projection period. The 1970 price relationships approximate those prevailing in the 1950's and 1960's when most of the basic data on end uses of timber products—the basis for projecting demands—were compiled. They also approximate the relative price relationships prevailing in the last months of 1974 and early 1975.

The medium projections of demand are also shown under two alternative price assumptions. This provides a basis for judging relative price changes likely to result from the prospective relationships between timber demands and supplies over the projection period.

Trends in the Major Timber Product Markets

Future demands for lumber and panel products—plywood, particleboard, hardboard, and insulation board—will be largely determined by trends in the major timber product markets—housing, nonresidential construction, manufacturing, and shipping.

Housing.—In terms of the volume of products consumed, residential construction is the most important market. In recent years, between a third and

[1] U.S. Department of Agriculture, Forest Service. The outlook for timber in the United States. Forest Resource Rpt. 20, 367 p. 1973.

Table 59. *Average annual demand for housing in the United States, by source of demand, 1920–70, with projections to 2020*

(*Thousand units*)

Period	Total demand	Household formations	Vacancies—conventional units	Net replacements			Mobiles not used as primary residences
				Total	Conventional units	Mobiles used as primary residences	
1920–29	803.4	556.6	239.0	7.8	.....	.....	.....
1930–39	365.1	496.2	–22.9	–108.2	.....	.....	.....
1940–49	809.0	800.5	80.7	–72.2	.....	.....	.....
1950–59	1,522.4	1,005.2	227.6	267.4	.....	.....	22.2
1960–69	1,648.7	1,039.3	–23.0	591.3	.....	.....	41.1
Low projections							
1970–79	2,340.0	1,490.0	140.0	610.0	500.0	110.0	100.0
1980–89	2,370.0	1,240.0	160.0	860.0	620.0	240.0	110.0
1990–99	2,070.0	850.0	140.0	990.0	700.0	290.0	90.0
2000–09	2,160.0	810.0	130.0	1,100.0	770.0	330.0	120.0
2010–19	2,120.0	670.0	100.0	1,220.0	820.0	400.0	130.0
Medium projections							
1970–79	2,460.0	1,550.0	160.0	640.0	520.0	120.0	110.0
1980–89	2,560.0	1,320.0	180.0	940.0	690.0	250.0	120.0
1990–99	2,360.0	970.0	190.0	1,090.0	790.0	300.0	110.0
2000–09	2,690.0	1,090.0	200.0	1,250.0	880.0	370.0	150.0
2010–19	2,730.0	1,000.0	170.0	1,400.0	950.0	450.0	160.0
High projections							
1970–79	2,580.0	1,630.0	170.0	670.0	540.0	130.0	110.0
1980–89	2,780.0	1,410.0	230.0	1,020.0	770.0	250.0	120.0
1990–99	2,800.0	1,180.0	280.0	1,210.0	890.0	320.0	130.0
2000–09	3,460.0	1,540.0	300.0	1,440.0	1,010.0	430.0	180.0
2010–19	3,660.0	1,510.0	260.0	1,690.0	1,150.0	540.0	200.0

Sources: Household formations: U.S. Department of Commerce, Bureau of the Census. 1920–60—United States census of housing, 1960. HC(1)-1. 1963; 1970—1970 Census of housing, Ser. HC(VI)-1. 1971.

Vacancies, conventional units—Forest Service estimates derived from data in the following sources: U.S. Department of Commerce, Bureau of the Census. *Historical statistics of the United States, colonial times to 1957.* 1960; 1970—Census of housing. Ser. HC(VI)-1. 1971.

Replacements—Forest Service estimates derived from data in the following sources: U.S. Department of Commerce, Bureau of the Census. *Historical statistics of the United States, colonial times to 1957.* 1960; *United States census of housing, 1960;* Vol. IV, Pt. 1-A. 1962.

Mobiles not used as primary residences—Forest Service estimates derived from data in U.S. Department of Commerce, Bureau of the Census. *United States census of housing, 1960.* Vol. IV, Pt. 1-A. 1962.

Projections: U.S. Department of Agriculture, Forest Service.

a half of the softwood lumber and plywood plus substantial volumes of hardwood plywood, particleboard, and insulation board have been used for the production, upkeep, and improvement of housing. This market is expected to continue to be large through the projection period.

Total U.S. housing production averaged about 1.65 million units per year during the 1960's, slightly above the average for the 1950's and about double the average number produced in the 1920's and 1940's (table 59, fig. 29).

Analyses of prospective household formations, housing replacements, and vacancy rates indicate a rise in housing demand in the late 1970's; and, by the 1980's, the medium projection of demand averages nearly 2.6 million units annually (table 59, fig. 29). There is a drop in the 1990's—a reflection of the decline in birth rates in the late 1960's and early 1970's. After that, demand again increases to an average of about 2.7 million units a year.

The type of housing unit demanded also is of major importance in projecting demands for timber products because of large differences in average per unit use. Prior to the 1960's, most new units were of the 1- or 2-family type (fig. 30). However, in the late 1950's, the proportion of multifamily units and mo-

Demand for new housing by source of demand 1920-74 with projections (medium level) to 2020

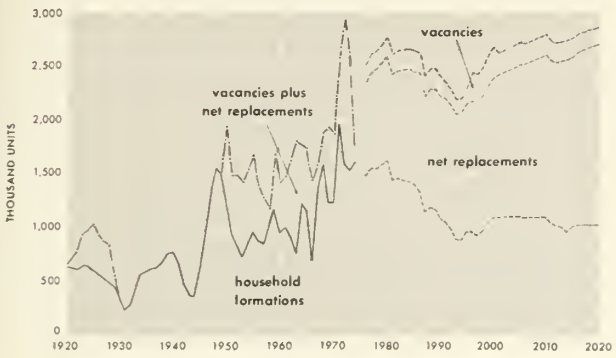

Figure 29

New housing unit production by type of unit, 1920-74, with projections (medium level) to 2020

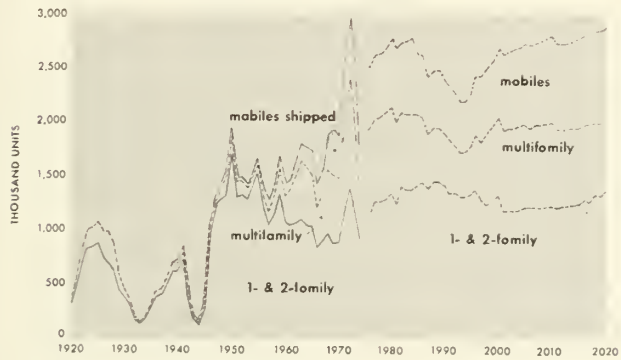

Figure 30

bile homes began to increase and by the early 1970's accounted for over half of all units produced.

Single-family housing units have typically been occupied by middle age classes, a reflection of family size and income. Occupancy of multifamily units and mobile homes, on the other hand, has been highest among the younger and older age classes, which usually have small families and relatively lower incomes. Because of prospective shifts in the age distribution of the population, demand for 1- and 2-family units is projected to increase until the late 1980's when it amounts to almost two-thirds of total demand. Projected demand for multifamily units—relatively high in the late 1970's and early 1980's—declines sharply through the early 1990's. After that, the situation reverses and multifamily units become relatively more important as the second generation effects of the post World War II "baby boom" are felt. Demand for mobile units used as primary residences follows about the same pattern in the 1980's and 1990's; however, the total demanded rises rapidly after 2000 because of replacement needs.

In addition to the timber products used in production of new residential units, substantial volumes are used annually for the upkeep and improvement of units in the existing housing inventory. Between 1960 and 1974, the years for which the most reliable data are available, expenditures for upkeep and improvements generally fluctuated between $12 and $13 billion annually (1967 dollars). For the purposes of this study, it was assumed that expenditures would grow at about the same rate as the housing inventory in the projection period. Under this assumption, projected annual expenditures rise to about $25.2 billion (medium level) by 2020. This involves a slight increase in annual expenditures per household.

Nonresidential construction.—About 10 percent of the lumber and plywood plus substantial volumes of building board used each year goes into nonresidential construction: (1) private commercial buildings (offices, stores, warehouses, etc.); (2) other buildings (public and private nonhousekeeping, industrial, educational, religious, hospital and institutional buildings); (3) utility, water, and sewer systems; (4) highways; and (5) all other (military facilities, conservation and development projects, railroad construction except track construction, and construction not included in other categories).

Although expenditures in these classes of construction have fluctuated rather widely in response to changing economic conditions, the longrun trend has been strongly upward. There have also been fairly close relationships between changes in expenditures for the major classes of nonresidential construction and changes in the gross national product. Projections based on these relationships show substantial increases for each class of construction over the projection period, ranging from around three times for highways to around five times for commercial buildings.

Total projected expenditures for new nonresidential construction rise from $49 billion (1967 dollars) in 1970 to $230 billion in 2020 (medium projection). The rates of growth underlying this projection, and the projections of manufacturing activity discussed below, decline fairly rapidly over the projection period. As a result, the transportation, trade, and other service sectors will account for a growing share of the projected gross national product. This is consistent with past trends. In the period 1950–68, for example, the portion of the gross national product originating in the service sectors rose from 46.5 to 49.6 percent.

Manufacturing.—About a tenth of the lumber, veneer and plywood, and a third of the hardboard and particleboard consumed in the United States is used in the manufacture of a wide range of products such as household furniture, consumer goods, commercial and industrial equipment, and other similar items.

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Pallet manufacture is a major market for hardwood lumber.

Shipments of manufactured products rose substantially in the 1948-70 period. There were also close relationships between changes in the value of shipments of each group of products and changes in gross national product or disposable personal income.

Projections to 2020 based on these past relationships vary from less than a threefold increase for "other products" to more than a fivefold increase for commercial and industrial equipment. As in the case of household furniture, assumed rates of increase in value of shipments drop significantly over the projection period for all product groups.

Shipping.—In 1970, about 15 percent of the lumber and 3 percent of the plywood consumed was used in the production of wood pallets, container manufacture, and for dunnage, blocking, and bracing. Over half of the lumber and about a quarter of the plywood was used in pallets.

In the 1950's and 1960's, pallet production rose very rapidly as new methods of materials handling were introduced and facilities geared to the use of pallets were constructed. Since the mid-1950's, there has been a close relationship between pallet output and manufacturing production.

Projections based on this relationship and assumed growth in industrial production indicate continuing large increases in demand for pallets. The medium projection at 1970 relative prices, for example, nearly triples by 2020. Rates of growth, however, drop rapidly from an average of 7.3 percent in the 1960's to 1.6 percent in the 1990's and 0.3 percent in the decade before 2020. Such a fall means that growth in pallet demand for use in new materials handling systems gradually ends, and that additional expansion depends to an increasingly larger degree on growth in industrial and agricultural production.

Markets for wooden containers declined in the 1950's in response to displacement by fiber and plastic containers, metal and fiber barrels and pails, and multiwall bags. Since about 1960, however, there has been a small rise in the demand as measured by value of shipments. In view of anticipated growth in manufacturing and agricultural production, continued modest increases have been projected.

In the past two decades, use of lumber for dunnage, blocking, and bracing in railroad cars, trucks, and ships has amounted to an estimated 800 million board feet a year. This stability, in a period of rapid increases in the volume of goods transported, apparently reflects effects of growth in palletized, containerized, and bulk shipments. Growth in such shipments is expected to continue. Consequently, demand for lumber for dunnage, blocking, and bracing has been projected to remain at recent levels.

Trends in Unit Use

The projected level of activity in the major markets discussed above is only one of the determinants of future demands for lumber, plywood, and panel products. Also important are changes in unit use, i.e., the volume of product used per dwelling unit, per pallet, per dollar of expenditure or other measure of market activity.

There have been widely divergent trends in unit use of the major products in the last two decades. The unit use of lumber has declined in most uses, especially in those such as housing where there has been extensive displacement by panel products. In contrast, unit use of plywood, building board, and particleboard has been rising.

In general, it has been assumed that recent trends in unit use would continue, but modified by a judgment evaluation of the various factors affecting future changes. For example, the rate of decline in the unit use of lumber in housing has been sharply reduced in recognition of the fact that much of the potential displacement by panel products has already taken place. New expectations about higher costs of fossil fuels, and other associated increases in the prices of many substitute materials such as steel, plastics, and aluminum have also been taken into account.

Projected Demand for Lumber and Panel Products

Based on the projections and expectations discussed above, the demand for lumber and panel products rises substantially in all major uses (tables 60, 61, and 62). In terms of volume, the largest increase for lumber is in shipping, and for plywood in

Table 60. *Lumber consumption in the United States, by species group and major end use, 1962 and 1970, with projections (1970 relative prices) to 2020*

Year	Total	Per capita average	By species group		By end use					
			Softwoods	Hardwoods	New housing	Residential upkeep and improvements	New non-residential construction[1]	Manu-facturing	Shipping	All other uses[2]
	Million board feet	*Board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*
1962	37,300	200	30,800	6,500	13,940	4,400	3,930	4,240	4,340	6,450
1970	39,500	193	32,100	7,300	12,270	4,690	3,690	4,670	5,720	8,460
Low projections[3]										
1980	49,320	222	40,440	8,880	16,340	5,410	4,570	5,660	7,080	10,260
1990	52,120	218	42,220	9,900	15,710	5,940	4,960	6,270	8,400	10,840
2000	52,580	209	42,060	10,520	14,070	6,300	5,420	6,850	9,000	10,940
2010	53,550	207	42,300	11,250	12,980	6,670	5,900	7,460	9,400	11,140
2020	54,050	205	42,160	11,890	12,240	6,880	6,350	7,740	9,600	11,240
Medium projections[3]										
1980	52,150	233	42,760	9,390	17,450	5,480	4,780	5,890	7,700	10,850
1990	56,780	230	45,990	10,790	17,370	6,060	5,330	6,810	9,400	11,810
2000	59,920	227	47,940	11,980	16,630	6,560	5,950	7,820	10,500	12,460
2010	63,860	226	50,450	13,410	16,680	7,080	6,720	8,900	11,200	13,280
2020	67,550	227	52,680	14,870	17,150	7,810	7,300	9,630	11,600	14,060
High projections[3]										
1980	55,300	242	45,340	9,960	18,580	5,520	5,100	6,230	8,380	11,490
1990	62,230	240	50,410	11,820	19,320	6,190	5,800	7,480	10,500	12,940
2000	68,980	241	55,180	13,800	20,080	6,860	6,660	8,930	12,100	14,350
2010	76,640	241	60,550	16,090	21,720	7,640	7,750	10,590	13,000	15,940
2020	82,080	234	64,020	18,060	22,480	8,410	8,710	11,910	13,500	17,070

[1] In addition to new construction includes railroad ties laid as replacements in existing track.

[2] Includes upkeep and improvement of nonresidential buildings and structures; farm construction except housing; mining; made-at-home projects such as furniture, boats, and picnic tables; made-on-the-job products like advertising and display structures; and a wide variety of other miscellaneous products and uses.

[3] Projections based on alternate assumptions about growth in population and economic activity as specified in the section on basic assumptions.

Note: Data may not add to totals because of rounding

Sources: Data for 1962 and 1970 based on information published by U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

Table 61. *Plywood consumption in the United States, by species group and major end use, 1962 and 1970, with projections (1970 relative prices) to 2020*

(3/8-inch basis)

Year	Total	Per capita average	By species group		By end use				
			Softwoods	Hardwoods	New housing	Residential upkeep and improvements	New non-residential construction	Manufacturing	All other uses[1]
	Million square feet	*Square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*
1962	11,716	63	9,311	2,404	4,180	1,030	1,280	1,870	3,356
1970	17,822	87	14,038	3,784	6,330	2,510	1,700	1,656	5,626
Low projections[2]									
1980	26,590	120	20,740	5,850	9,860	3,300	2,690	2,340	8,400
1990	29,750	124	23,205	6,545	10,280	3,930	3,280	2,860	9,400
2000	31,670	126	24,705	6,965	9,670	4,390	4,020	3,580	10,010
2010	34,360	133	26,800	7,560	9,330	4,900	4,750	4,520	10,860
2020	36,420	138	28,410	8,010	8,960	5,220	5,300	5,430	11,510
Medium projections[2]									
1980	27,850	124	21,725	6,125	10,530	3,350	2,770	2,400	8,800
1990	32,270	131	25,170	7,100	11,390	4,010	3,540	3,130	10,200
2000	35,960	136	28,050	7,910	11,460	4,570	4,470	4,100	11,360
2010	41,210	146	32,145	9,065	11,980	5,200	5,630	5,380	13,020
2020	45,950	154	35,840	10,110	12,480	5,920	6,220	6,810	14,520
High projections[2]									
1980	29,300	128	22,840	6,460	11,200	3,370	2,910	2,550	9,270
1990	35,230	136	27,480	7,750	12,680	4,100	3,840	3,480	11,130
2000	41,490	145	32,360	9,130	13,840	4,780	5,030	4,730	13,110
2010	49,870	157	38,900	10,970	15,590	5,610	6,520	6,390	15,760
2020	56,930	162	44,405	12,525	16,850	6,380	7,420	8,290	17,990

[1] Includes shipping; upkeep and improvement of nonresidential buildings and structures; farm construction except housing; mining; made-at-home projects such as furniture and boats; made-on-the-job products like advertising and display structures; and a wide variety of other miscellaneous products and uses.

[2] Projections based on alternate assumptions about growth in population and economic activity as specified in the section on basic assumptions.

Note: Veneer is included in the estimates for manufacturing and shipping.

Sources: Data for 1962 and 1970 based on data published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

Table 62. *Board consumption in the United States, by type of board and major end use, 1970, with projections (1970 relative prices) to 2020 (3/8-inch basis)*

Year	Total	Per capita average	By type of board			By end use				
			Insulation board	Hardboard	Particle-board	New housing	Residential upkeep and improvements	New non-residential construction	Manu-facturing	All other uses[1]
	Million square feet	*Square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*
1970	9,608	47	4,552	1,541	3,515	2,760	1,415	960	1,790	2,683
Low projections[2]										
1980	15,565	70	4,980	2,490	8,095	4,225	1,900	1,305	3,465	4,670
1990	19,540	82	5,470	3,320	10,750	4,575	2,450	1,560	5,095	5,860
2000	23,270	93	6,515	4,190	12,565	4,655	2,790	1,665	7,180	6,980
2010	28,615	110	8,015	5,150	15,450	4,945	3,190	1,695	10,200	8,585
2020	34,250	130	9,590	6,165	18,495	5,295	3,390	1,705	13,585	10,275
Medium projections[2]										
1980	16,210	72	5,350	2,595	8,265	4,495	1,930	1,345	3,575	4,865
1990	21,205	86	5,940	3,815	11,450	5,135	2,490	1,705	5,515	6,360
2000	26,405	100	7,395	5,015	13,995	5,575	2,920	1,840	8,150	7,920
2010	33,390	118	9,350	6,345	17,695	6,265	3,400	1,945	11,765	10,015
2020	41,935	141	11,740	7,970	22,225	7,225	3,870	2,055	16,205	12,580
High projections[2]										
1980	17,050	74	5,795	2,730	8,525	4,785	1,940	1,415	3,795	5,115
1990	23,105	89	6,700	4,390	12,015	5,680	2,540	1,840	6,115	6,930
2000	30,535	107	8,245	6,715	15,575	6,665	3,050	2,065	9,595	9,160
2010	40,880	129	11,035	8,995	20,850	8,095	3,640	2,265	14,615	12,265
2020	53,505	152	14,445	11,770	27,290	9,745	4,150	2,440	21,120	16,050

[1] Includes upkeep and improvement of nonresidential buildings and structures; shipping, farm structures, except housing; mining, made-at-home projects such as furniture; made-on-the-job products like advertising and display structures; and a wide variety of other miscellaneous products and uses.

[2] Projections based on alternate assumptions about growth in population and economic activity as specified in the section on basic assumptions.

Sources: Data for 1970 based on data published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

housing. The largest increase for board—insulation board, hardboard, and particleboard—is in manufacturing.

In addition to the major end uses covered above, an estimated 8.5 billion board feet of lumber, 5.6 billion square feet of plywood, and 2.7 billion square feet of board were used in 1970 for other purposes. These included upkeep and improvement of nonresidential structures; farm construction except housing; structures and roof supports in mines; made-at-home products such as furniture, boats, and picnic tables; and made-on-the-job products such as advertising and display structures.

There are no historical data available showing actual consumption of timber products in these various uses. Accordingly, timber products use for these purposes in 1962 and 1970 was estimated by subtracting volumes of timber products consumed in the specific end uses discussed above from estimated total consumption of each product. This residual probably includes some volumes which properly belong in the construction, manufacturing, or shipping sectors. The figures also include any statistical discrepancies associated with the estimates of production, imports, and exports used in estimating total consumption.

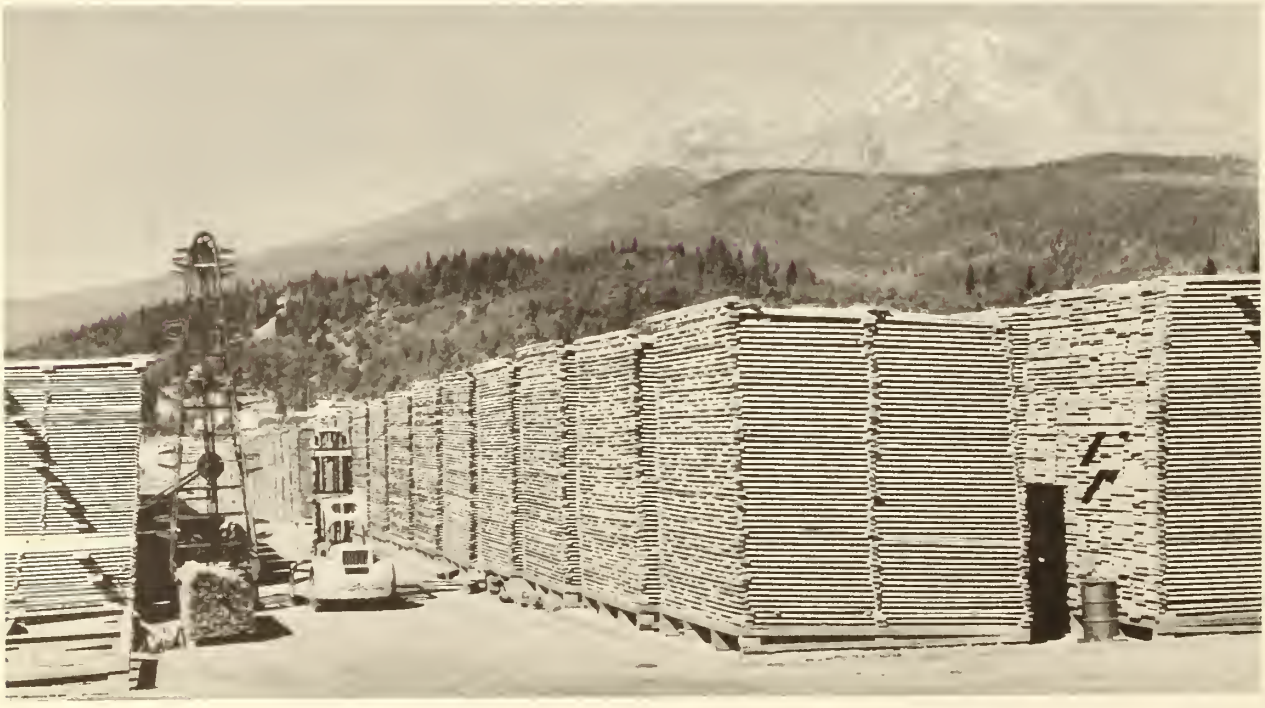
Because of the lack of a statistical base for projections of demand for these residual uses, it was assumed that demands for these purposes would rise in line with projected demands for the total of all other items.

Lumber.—Lumber consumption in all uses in 1974 was 40.4 billion board feet, a volume close to the average of the 1950's and 1960's. Projected demand for lumber at 1970 relative prices shows a rather steep rise to a 1980 level of 52 billion board feet (table 60). This growth is attributable largely to the rise in demands for housing and pallets. After 1980, primarily because of the leveling off in housing, projected demand at 1970 prices increases more slowly to 67.6 billion board feet in 2020.

In recent decades, softwoods have composed around four-fifths of the lumber consumed. This proportion is expected to be maintained without much change.

The alternative assumptions on population and economic growth discussed in the assumptions section (pages 7–11) have substantial impacts on the demand for lumber in all end uses (table 60). In 2020, for example, projected total demand at 1970 relative prices ranges from 54.0 billion board feet to 82.1 billion board feet.

Plywood.—Plywood consumption in 1974 was 19.3 billion square feet (3/8-inch basis)—more than twice the volume consumed in 1960 and about five times that of 1950. At 1970 relative prices, the medium projection of demand rises to 46 billion square feet in 2020, more than double average consumption in the past 4 years (table 61). As in the case of lumber, the alternative assumptions on growth in population and economic activity have substantial impacts on projected demand.



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The demand for lumber, given constant relative prices, shows a rather steep rise in the decades ahead.

Since the late 1950's, softwood plywood has composed about four-fifths of total plywood consumption. An analysis of prospective growth in demand by major end uses indicates that this percentage is likely to remain about the same through the projection period.

Board.—Board consumption, including insulation board, hardboard, and particleboard, reached 11.7 billion square feet (3/8-inch basis) in 1974—nearly 3.5 times the volume consumed in 1950. Particleboard accounted for much of the increase, with consumption rising from less than 50 million square feet in 1950 to 5.3 billion in 1974. Hardboard use also rose rapidly. Although consumption of insulation board has been relatively stable, this product still accounted for about 36 percent of the board consumed in 1974.

Projections of demand for board (medium level) at 1970 relative prices reach 41.9 billion square feet (3/8-inch basis) by 2020—some 3.6 times the volume consumed in 1974 (table 62). Particleboard and hardboard are expected to continue to show the largest increases. Under the alternative assumptions on growth in population and economic activity, projected total demands in 2020 range from about 34 to 54 billion square feet.

Projected Demand for Pulpwood

Since 1920, pulpwood consumption in U.S. mills has increased thirteenfold, rising to 6.4 billion cubic feet in 1974[2] (82.2 million cords). Export demand, including the pulpwood equivalent of pulp and paper, increased 24 times to 0.9 billion cubic feet (12.1 million cords). As a result of such growth, about half of the cubic volume of timber harvested from domestic forests is used as pulpwood.

Demand for pulpwood is a derived demand in the sense that it is determined by demands for paper, board, and other pulp products. Consumption of paper and board has risen from about 8 million tons in 1920 to 65.5 million tons in 1974. Per capita consumption has also increased rapidly from 145 pounds to 618 pounds.

Consumption of most of the major grades of paper and board has increased substantially in recent years. However, there have been large differences in their rates of growth. These have resulted from factors such as changes in consumer tastes, development of new pulp-based products, inroads of substitutes, and varying rates of growth in major sectors of the economy. In partial recognition of these differences, the various types and grades of paper and board have been grouped into three categories—paper, paperboard, and building board (insulation board and hardboard)—which have a common relationship to one or more of the basic determinants of demand discussed in the introductory section of this study.

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Tremendous quantities of wood—82 million cords in 1974—are used in the domestic manufacture of wood pulp. Nearly all of this pulp is made into paper and board.

Most paper is consumed in one form or another by individuals, with their level of use a function of income. Consequently, there has been a close statistical relationship between changes in per capita consumption of paper and changes in per capita disposable personal income. In the case of paperboard, which is used primarily for packaging industrial and agricultural commodities, per capita consumption has shown a closer relationship to changes in the per capita gross national product. Most of the growth in the consumption of building board, which is used in construction for such purposes as sheathing and underlayment and in manufacturing, has been associated with changes in these sectors of the economy.

On the basis of past relationships and trends, total demand for paper, paperboard, and building board at 1970 relative prices is projected to rise to 147 million tons (medium level) in 2000, and to 225 million tons in 2020—some 3.4 times consumption in 1974. Projections of per capita demand also rise rapidly, reaching 1,114 pounds in 2000 and 1,510 pounds in 2020 although the annual rates of growth drop fairly rapidly.

Effects of the alternative assumptions of growth in population and gross national product are substantial, with projected total demand for paper and board ranging from 123 million tons to 181 million tons in 2000.

In addition to changes in demand for paper and board, future demand for pulpwood will be strongly influenced by the amounts and kinds of fibrous materials used in its manufacture. Since the 1920's, av-

[2] This included 4.3 billion cubic feet of roundwood and 2.1 billion cubic feet of chips and sawdust obtained from slabs, edgings, veneer cores, and other residues of primary manufacturing plants.

erage use of fibrous materials per ton of production (all grades combined) has shown little variation, ranging from 0.992 to 1.092 tons.

Although there has not been much change in the amount of fibrous materials used per ton of production, there have been changes in the mix of fibers consumed. In the last two decades, new woodpulp has risen from roughly 64 percent of the total fibrous mix to around 80 percent. Use of wastepaper, on the other hand, declined from 31 percent of the total fibers used in 1950 to around 19 percent in 1972. Use of other fibers dropped from about 5 percent to less than 2 percent.

In recent years, a number of forces have developed—concern about the environment, problems of solid waste disposal, increasing competition for timber—which point to the likelihood of substantial growth in recycling wastepaper. Use of recycled fibers per ton of paper and board produced has therefore been assumed to rise from 0.19 ton in 1972 to 0.35 ton by 2000 and to 0.40 ton by 2020. The latter level is close to current rates in Japan and the Netherlands, and to the rate achieved for a time in the United States during World War II. Projected use of new woodpulp drops from 0.81 ton in 1970 to 0.62 ton in 2020. Use of other fibrous materials remains unchanged.

Despite the decline in use per ton, demand for woodpulp for the manufacture of paper and board rises rapidly through the projection period. Demand for woodpulp for the manufacture of rayon, plastics, and other nonpaper products also increases.

Because of offsetting trends resulting from changes in pulping technology, grades of paper produced, and species of wood used, average consumption of pulpwood per ton of pulp produced has not changed significantly in the past 50 years. It has been assumed, however, that the net effects of continuing technological developments and further increases in use of high yield hardwoods, will cause a decline in consumption of pulpwood per ton of pulp produced from an average of about 1.6 cords in 1974 to 1.5 cords in 2000 and beyond.

Given the above projections and assumptions, total demand for pulpwood—domestic and export—rises to 173 million cords in 2000, with a further increase to 233 million cords in 2020. These volumes are, respectively, 1.7 times and 2.3 times the 102 million cords consumed in 1974. As indicated in the tabulation below, the alternative assumptions on growth in population and economic activity have large impacts on pulpwood demand in the decades beyond 1980.

Year	*Total pulpwood demand—export and domestic (million cords)*		
1974	102.0		
	Low projections	*Medium projections*	*High projections*
1980	111.8	117.9	125.9
1990	129.5	144.7	163.5
2000	147.5	172.6	207.4
2010	165.8	205.5	263.0
2020	178.9	232.6	316.0

Part of the demand for pulpwood by U.S. mills has been met by the use of slabs, edgings, veneer cores, sawdust, and other byproducts produced at primary manufacturing plants. Between 1950 and 1974, use of these materials increased from 1.2 million cords to 27.1 million cords. Although most of the economically available coarse material and some fines are currently utilized, it is estimated that unused volumes of chippable residues are large enough to permit an increase to 36.5 million cords.[3] Most of this increase is expected to take place by the early 1980's.

Given this estimate of byproduct use, the demand for roundwood (domestic and export) for pulping will rise from 74.9 million cords in 1974 to 137.6 million cords in 2000 with a further increase to 196.1 million cords in 2020.

Projected Demand for Other Timber Products

As shown in the tabulation below, a variety of miscellaneous industrial roundwood products are consumed in the United States.

Total consumption of these products amounted to 424 million cubic feet in 1970. This was somewhat

[3] The estimates of byproducts use are based upon the projections of timber supplies likely to be available for lumber and plywood production (with 1970 levels of forest management).

Product	*Standard unit of measure*	*1952*	*1962*	*1970*
Cooperage	Million board feet	355.3	216.0	214.7
Piling	Million linear feet	41.2	41.5	28.8
Poles	Million pieces	6.5	6.7	5.4
Posts	Million pieces	306.0	168.7	97.7
Mine timbers	Million cubic feet	81.0	48.4	32.1
Other industrial products[1]	Million cubic feet	235.2	157.6	198.8
All miscellaneous products	Million cubic feet	698.8	465.4	424.0

[1] Includes charcoal wood, roundwood used in the manufacture of particle-board; poles and rails used in fencing; bolts used for products such as shingles, wood turnings, and handles; and other miscellaneous items such as hop poles.

below the general level of the 1960's when estimated consumption averaged about 500 million cubic feet per year, and far below consumption of more than 2 billion cubic feet annually in the early 1900's.

Additional volumes of plant byproducts such as sawdust, slabs, and edgings used in the production of charcoal, chemicals, and various other goods amounted to 185 million cubic feet in 1970. Thus, total wood consumption for miscellaneous products in that year amounted to a little over 600 million cubic feet.

The downward trend in consumption of miscellaneous industrial roundwood products which began around 1910 appears to have bottomed out in recent years. For this report, it was therefore assumed that demand for these products will remain close to 500 million cubic feet. However, individual products are likely to show divergent trends as in the past.

Fuelwood consumption in 1970 was an estimated 16 million cords. This included approximately 311 million cubic feet of roundwood from growing stock trees and 227 million cubic feet of roundwood from other sources such as dead and cull trees, plus 727 million cubic feet of primary plant residues. Fuelwood cut from roundwood was used almost entirely for domestic heating and cooking. Plant residues were used both for domestic purposes and for steam power in wood processing plants.

The volume of roundwood used for fuel dropped sharply in the first five decades of the present century because of the substitution of oil, gas, coal, and electricity in home cooking, heating, and industrial uses. In recent years, however, substantial markets have developed in metropolitan areas for fireplace wood. Expected increases in income, population, and residential construction indicate this market may continue to grow. Consequently, it has been assumed that demand for round fuelwood would continue at about the 1970 level through the projection period although new air pollution standards could reduce this demand.

Projected Demand for Timber

The projections of demand for timber products presented above have been in standard units of measure, that is, board feet of lumber, square feet of plywood, cords of pulpwood and fuelwood, and cubic feet of miscellaneous industrial roundwood products. In order to facilitate comparisons of demand for these products with subsequent estimates of timber supplies, these projections must be converted to common units of measure—cubic feet of roundwood and board feet of sawtimber.

Improvements in utilization.—An important factor in converting demands for timber products to roundwood is prospective change in utilization practices. During the past couple of decades, there have been

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There have been substantial improvements in the utilization of timber harvested from domestic forests in recent decades. Most of the improvement has come from the use of chips produced from slabs, edgings, and veneer cores—formerly residues of lumber and plywood mills—in the manufacture of wood pulp.

substantial improvements in utilizing the timber harvested from U.S. forests. Improvements have largely involved the growing use of slabs, edgings, sawdust, veneer cores, shavings, and other similar material for pulp and particleboard. Various technological changes have also led to increased product yield per unit of wood input although in the lumber industry this has apparently been offset by the use of smaller and lower quality material and the spreading use of chipping headrigs. Yields in the pulp industry have been held down by a sharp rise in the production of bleached and semibleached pulps which require more wood per ton of production.

With respect to the future, it has been assumed that there would be significant increases in timber product yields over the projection period. The assumed increases from the 1970 base (and 1970 relative prices) range from about 6 percent for woodpulp to about 15 percent for softwood lumber and plywood. These percentages are larger under the alternative higher price assumptions discussed below.

Projected demands for roundwood.—In 1974, U.S. consumption of timber products in terms of roundwood volume was 13.1 billion cubic feet, about 6 percent below the high of 13.9 billion cubic feet

reached in 1973, but significantly above the levels of the 1960's when consumption was generally below 11.5 billion cubic feet a year.

As indicated in the tabulation below, there are substantial increases in projected roundwood demands under all the assumptions on growth in population and economic activity. For example, the medium projection of demand reaches 16.6 billion cubic feet in 1980, with a continuing rise to 27.8 billion cubic feet in 2020—some 2.1 times consumption in 1974. Most of the projected growth in demand is for pulp products, consequently pulpwood accounts for over half of the total demand for roundwood in 2020.

Total roundwood consumption and projected demand (billion cubic feet)

1974	13.1		
	Low projections	*Medium projections*	*High projections*
1980	15.5	16.6	17.8
1990	17.1	19.2	21.7
2000	18.6	22.0	26.2
2010	20.1	25.1	32.0
2020	21.2	27.8	37.3

Growth in roundwood consumption in the 1950's and 1960's consisted entirely of timber produced from softwood species. Consumption of hardwood roundwood declined with a drop in use of miscellaneous industrial timber products and fuelwood. However, this trend was reversed in the early 1970's largely in response to increased use of lumber in furniture and pallet manufacture, continuing rises in hardwood pulpwood, and slowing in the rate of decline in fuelwood consumption.

Projections show rather large increases for both softwoods and hardwoods. Assuming 1970 relative prices, for example, the medium projection of demand for softwoods almost doubles by 2020—from 9.7 to 18.8 billion cubic feet. Demand for hardwoods is projected to nearly triple, rising from 3.0 to 9.0 billion cubic feet. The faster rate of growth for hardwoods largely reflects the projected rise in demand for hardwood roundwood for pulp products, hardwood lumber for pallets, and hardwood plywood and veneer for furniture manufacture.

Demand for sawtimber products.—About 70 percent of the roundwood consumed in 1970 came from the saw-log portion of sawtimber trees. Trends in consumption of sawtimber have been very similar to the trends for total roundwood, that is, a fairly rapid upward movement in the 1960's and early 1970's. The projections show this similarity continuing.

As was the case with roundwood, the alternative assumptions on population and economic activity result in a substantial range in projected demand for sawtimber. By 2020, projected demands at 1970 prices vary from about 84.1 billion to 139.0 billion board feet—levels that are, respectively, 23 percent below and 28 percent above the medium level.

Impacts of Price Changes on Projected Demand for Timber

Past increases in timber product prices, both in actual terms and relative to competing materials, have undoubtedly been an important determinant of the levels of consumption of timber products. A number of closely related factors such as installation and maintenance costs, performance, useful life, and market promotion efforts have likewise affected actual and relative use.

As indicated earlier, the projections of demand discussed above were developed under the assumption that 1970 prices of timber products relative to average wholesale prices of all commodities and to most competing materials would not change significantly during the projection period. These were the price relationships prevailing during most of the 1950's and 1960's when much of the basic data on timber products use were compiled for this study. They were also approximately the relationships prevailing at the end of 1974 and early 1975.

The 1970 price relationships could be expected to prevail only if supplies of stumpage meet demands at 1970 prices through the projection period—which later analyses indicate is not likely—and if productivity in the timber processing industries keeps pace with that in other industries.

In the past, these conditions have not held for periods longer than a decade or two, and prices of stumpage and of most timber products have shown persistent longrun upward trends relative to the general price level (figs. 31 and 32). Timber product prices have also shown longrun rising trends relative to important competing raw materials such as iron, aluminum, and nonmetallic minerals.

In recognition of the likelihood of future price increases and to determine potential effects of alternative price levels on demand and estimate the size of price changes resulting from prospective future imbalances between supply and demand, the medium projections of demand were estimated under two alternative price assumptions (alternatives to 1970 prices).

One set was based on the assumption that the relative wholesale prices of lumber and plywood would be 30 percent above 1970 average relative prices, miscellaneous products and fuelwood 15 percent, and paper and board 10 percent throughout the projection period. The assumed level for lumber and plywood approximates the actual increases in relative softwood lumber and plywood prices between 1970 and 1972.

A second set of alternative projections was developed under the assumption that relative wholesale

Stumpage prices for Douglas-fir and southern pine 1910 - 74

Figure 31

Relative wholesale price index of lumber 1800 - 1974

Figure 32

prices of timber products would rise from the 1970 trend level through the projection period much as in the past. For lumber, the assumed average annual increase for these "rising" prices was 1.5 percent. For plywood, miscellaneous products, and fuelwood, a 1.0 percent rise per year was assumed, and for paper and board 0.5 percent.

In preparing projections of demand for lumber and other timber products under these alternative price assumptions, it was also necessary to make certain assumptions about the quantitative effects of relative price increases on projected demands.

General observation of timber markets indicates that, in the shortrun, price changes may have only limited effects on quantities of timber products that consumers will buy. For example, the spectacular rise in lumber and plywood prices in 1968–69, and a similar rise in 1971–74, appears to have had very limited initial impacts on consumption of these products in most end uses. Over the longer run, however, sustained upward shifts in prices of timber products relative to the wholesale price level and to competing products would lead to reduced demands for timber.

Longrun trends in lumber consumption and relative prices appear to illustrate this effect. Despite the very large expansion of major markets in construction, manufacturing, and shipping during the present century, lumber consumption in 1970 approximated the consumption level of the early 1900's. Presumably, the increase in relative lumber prices—averaging 1.6 percent per year in this period—was an important factor leading to increased use of substitutes and other changes affecting lumber uses.

In contrast to lumber, the demand for paper seems to be rather insensitive to price changes. This is believed to reflect the lack of acceptable low-cost substitutes for paper and board in most end uses. Also, for many items such as books, tissue paper, and various kinds of containers, the cost of paper or board to the final consumer is so small in relation to the total price of the product, or the consumer income, that even fairly large percentage changes in paper and board prices appear unlikely to have much impact on consumption.

Although such general relationships between timber product prices and demand seem reasonably clear, there are as yet no validated quantitative measures of the longrun impacts of price increases on demand. Estimates were therefore developed on a judgment basis to indicate the changes in demand expected to result from changes in product prices, as in the tabulation below.

The effects of the above assumptions on the medium projections of demand for timber are summarized in tables 63 and 64. Actual changes in future

Change in demand resulting from a sustained 1 percent rise in relative prices

Years after price increase	*Lumber, plywood, and miscellaneous products (percent)*	*Paper and board (percent)*
1st	–0.1	–0.05
5th	–0.3	–0.1
10th	–0.5	–0.2

Table 63. *Summary of roundwood consumption in the United States, by species group and major product, 1952, 1962, and 1970, with projections of demand (medium level[1]) under alternative price assumptions to 2020*

(Billion cubic feet, roundwood equivalent)

Year	All species						Softwoods						Hardwoods					
	Total[2]	Saw logs	Veneer logs	Pulpwood [3]	Miscellaneous Products [4]	Fuelwood	Total[2]	Saw logs	Veneer logs	Pulpwood [3]	Miscellaneous Products [4]	Fuelwood	Total[2]	Saw logs	Veneer logs	Pulpwood [3]	Miscellaneous Products [4]	Fuelwood
1952	11.9	6.1	0.4	2.7	0.7	2.0	8.4	5.0	0.2	2.4	0.3	0.5	3.5	1.1	0.2	0.3	0.4	1.5
1962	11.6	5.7	.9	3.3	.5	1.1	8.5	4.8	.6	2.6	.3	.2	3.1	1.0	.2	.7	.2	.9
1970	12.7	6.1	1.2	4.4	.4	.5	9.7	5.0	.9	3.4	.2	.1	3.0	1.1	.3	1.0	.2	4
1970 relative prices																		
1980	16.6	7.9	1.9	5.8	.5	.5	12.3	6.3	1.5	4.1	.3	.1	4.3	1.6	.4	1.7	.2	.4
1990	19.2	8.4	2.1	7.7	.5	.5	13.8	6.6	1.7	5.1	.3	.1	5.4	1.8	.4	2.6	.2	.4
2000	22.0	8.8	2.4	9.8	.5	.5	15.4	6.8	1.9	6.3	.3	.1	6.6	2.0	.5	3.5	.2	.4
2010	25.1	9.3	2.6	12.2	.5	.5	17.2	7.1	2.0	7.7	.3	.1	7.9	2.2	.6	4.5	.2	.4
2020	27.8	9.8	2.8	14.2	.5	.5	18.8	7.4	2.2	8.8	.3	.1	9.0	2.4	.6	5.4	.2	.4
Rising relative prices[5]																		
1980	15.2	6.9	1.6	5.7	.5	.5	11.3	5.5	1.3	4.1	.3	.1	3.9	1.4	.3	1.6	.2	.4
1990	16.6	6.6	1.7	7.4	.4	.5	12.1	5.2	1.4	5.2	.2	.1	4.5	1.4	.3	2.2	.2	.4
2000	18.2	6.2	1.8	9.4	.3	.5	12.8	4.8	1.4	6.3	.2	.1	5.4	1.4	.4	3.1	.1	.4
2010	20.1	5.8	1.8	11.7	.3	.5	13.9	4.4	1.4	7.8	.2	.1	6.2	1.4	.4	3.9	.1	.4
2020	22.1	5.5	2.0	13.8	.3	.5	14.8	4.1	1.5	8.9	.2	.1	7.3	1.4	.5	4.9	.1	.4
Relative prices above 1970 averages[6]																		
1980	14.6	6.5	1.6	5.6	.4	.5	10.7	5.2	1.2	4.0	.2	.1	3.9	1.3	.4	1.6	.2	.4
1990	17.2	7.0	1.8	7.5	.4	.5	12.4	5.5	1.4	5.2	.2	.1	4.8	1.5	.4	2.3	.2	.4
2000	19.6	7.4	2.0	9.3	.4	.5	13.7	5.7	1.5	6.2	.2	.1	5.9	1.7	.5	.5	.2	.4
2010	22.6	7.8	2.1	11.8	.4	.5	15.6	6.0	1.6	7.7	.2	.1	7.0	1.8	.5	4.1	.2	.4
2020	25.4	8.2	2.4	13.9	.4	.5	17.2	6.2	1.8	8.9	.2	.1	8.2	2.0	.6	5.0	.2	.4

1 Based on the medium projections of growth in population and economic activity shown in the section on basic assumptions.

2 Includes imported logs not shown by major product use.

3 Includes both pulpwood and the pulpwood equivalent of the net imports of woodpulp, paper, and board.

4 Includes cooperage logs, poles, piling, fence posts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, and other miscellaneous items.

5 Relative prices rising from 1970 trend levels as follows: lumber—1.5 percent per year; plywood, miscellaneous products, and fuelwood—1.0 percent per year; paper and board—0.5 percent per year.

6 Relative prices of lumber and plywood—30 percent, miscellaneous products and fuelwood—15 percent, and paper and board—10 percent, above the 1970 averages.

Note: Columns may not add to totals because of rounding.

Sources: 1952, 1962, and 1970—Based on data published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

Table 64. *Summary of sawtimber consumption in the United States, by species group and major product, 1952, 1962, and 1970, with projections of demand (medium level[1]) under alternative price assumptions to 2020*

(Billion board feet, International 1/4-inch log rule)

Year	All species						Softwoods						Hardwoods					
	Total[2]	Saw logs	Veneer logs	Pulpwood	Miscellaneous Products[3]	Fuelwood	Total[2]	Saw logs	Veneer logs	Pulpwood	Miscellaneous Products[3]	Fuelwood	Total[2]	Saw logs	Veneer logs	Pulpwood	Miscellaneous Products[3]	Fuelwood
1952	51.6	39.0	3.0	4.7	2.4	2.3	39.9	31.8	1.9	4.3	1.2	.6	11.6	7.1	1.1	4	1.2	1.7
1962	53.3	37.2	6.5	7.2	1.5	.8	41.7	30.8	4.9	5.0	.9	.1	11.7	6.5	1.6	2.2	.6	.7
1970	59.9	38.9	8.6	10.2	1.7	.4	47.6	31.6	6.8	8.0	1.0	.1	12.3	7.3	1.8	2.2	.7	.3
1970 relative prices																		
1980	76.0	48.5	12.9	12.3	1.7	.4	59.3	39.4	10.3	8.4	1.0	.1	16.7	9.1	2.6	3.9	.7	.3
1990	84.0	51.7	14.5	15.5	1.7	.4	64.0	41.3	11.4	10.1	1.0	.1	20.0	10.4	3.1	5.4	.7	.3
2000	91.2	53.7	16.2	19.0	1.7	.4	68.1	42.3	12.8	11.8	1.0	.1	23.1	11.4	3.4	7.2	.7	.3
2010	100.3	56.9	17.7	23.4	1.7	.4	73.3	44.2	13.9	14.0	1.0	.1	27.0	12.7	3.8	9.4	.7	.3
2020	108.6	59.8	19.9	26.6	1.7	.4	77.7	45.7	15.6	15.2	1.0	.1	30.9	14.1	4.3	11.4	.7	.3
Rising relative prices[4]																		
1980	67.3	42.4	11.5	11.2	1.6	.4	52.4	34.4	9.2	7.7	.9	.1	14.9	8.0	2.3	3.5	.7	.3
1990	68.7	40.9	12.1	13.6	1.5	.4	52.3	32.6	9.7	8.9	.9	.1	16.4	8.3	2.4	4.7	.6	.3
2000	68.9	38.2	12.2	16.5	1.4	.4	50.9	29.9	9.7	10.3	.8	.1	18.0	8.3	2.5	6.2	.6	.3
2010	70.6	35.8	12.5	20.3	1.4	.4	50.7	27.7	9.9	12.1	.8	.1	19.9	8.1	2.6	8.2	.6	.3
2020	71.8	33.5	13.0	23.4	1.3	.4	50.2	25.5	10.3	13.4	.8	.1	21.6	8.0	2.7	10.0	.5	.3
Relative prices above 1970 averages[5]																		
1980	63.5	39.9	10.5	10.9	1.6	.4	49.2	32.3	8.3	7.5	.9	.1	14.3	7.6	2.2	3.4	.7	.3
1990	70.9	43.2	11.8	13.7	1.6	.4	53.8	34.4	9.3	9.0	.9	.1	17.1	8.8	2.5	4.7	.7	.3
2000	77.6	45.2	13.1	17.1	1.6	.4	57.6	35.5	10.4	10.6	.9	.1	20.0	9.7	2.7	6.5	.7	.3
2010	86.0	47.9	14.4	21.5	1.6	.4	62.4	37.1	11.3	12.9	.9	.1	23.6	10.8	3.1	8.6	.7	.3
2020	93.4	50.4	16.0	24.8	1.6	.4	66.3	38.4	12.6	14.2	.9	.1	27.1	12.0	3.4	10.6	.7	.3

1 Based on the medium projections of growth in population and economic activity shown in the section on basic assumptions.

2 Includes imported logs not shown by major product use.

3 Includes cooperage logs, poles, piling, fence posts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, and other miscellaneous items.

4 Relative prices rising from 1970 trend levels as follows: lumber—1.5 percent per year; plywood, miscellaneous products, and fuelwood—1.0 percent per year; paper and board—0.5 percent per year.

5 Relative prices of lumber and plywood—30 percent, miscellaneous products and fuelwood—15 percent, and paper and board—10 percent, above the 1970 averages.

Note. Columns may not add to totals because of rounding.

Sources: 1952, 1962, and 1970—Based on data published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

consumption and in equilibrium prices of timber products and stumpage—in contrast to the selected price assumptions presented above—will be determined both by future trends in demands for timber products and by availability of domestic timber supplies. Such comparisons of timber demands and supplies, and related price implications, are presented in a following part of this section. Before these comparisons can be made, however, total demands for timber products must be converted to demands on domestic forests by taking into account projected imports and exports of timber products.

Trade in Timber Products

In the early 1900's, the United States changed from a net exporter of timber products to a net importer, and since that time, a growing part of U.S. demands has been met by imports.

Trends in Timber Product Imports

Most of the growth in timber product imports has occurred since the early 1950's, a period when the volume increased from 1.4 billion cubic feet, roundwood equivalent,[4] to a 1973 peak of 3.1 billion (fig. 33). The 1973 imports represented a fifth of the total supply of timber products in the United States.

Imports and exports of timber products

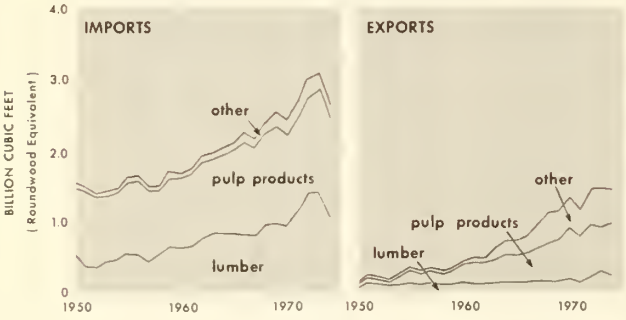

Figure 33

Between 1950 and 1973, lumber imports rose from 0.5 billion cubic feet (3.4 billion board feet) to 1.4 billion cubic feet (9.6 billion board feet)—a rise that accounted for over half of the total growth in imports during this period. Nearly all of the increase in lumber imports was composed of softwoods from Canada, chiefly from British Columbia. Hardwood lumber imports, mostly from the tropical regions of the world and Canada, fluctuated between 0.2 and 0.4 billion board feet per year.

Imports of woodpulp, newsprint, and other grades of paper and board have also increased since 1950 reaching 1.5 billion cubic feet in 1973. Nearly all of these imports have originated in Canada.

Although not large in terms of cubic volume, hardwood plywood and veneer imports have shown very rapid growth since 1950, rising from 5 million to a peak of 265 million cubic feet in 1972. Korea, Taiwan, Japan, and the Philippines have been the source of nearly all the added imports. Most of the timber used in the manufacture of these products, however, has originated in tropical hardwood forests in the Philippines, Malaysia, and Indonesia.

Small volumes of logs, softwood plywood, particleboard, and miscellaneous roundwood products such as posts and poles also have been imported. Most of these imports have been cross-border trade with Canada.

The increase in imports of timber products reflects such factors as rising consumption of industrial timber products in the United States, a tightening domestic timber supply situation and economic development of timber resources in Canada and the Western Pacific Area, and effective marketing efforts by timber producers in exporting countries.

Trends in Timber Product Exports

Exports of timber products in recent years have followed about the same upward trend as imports, rising from 0.1 billion cubic feet in 1950 to 1.5 billion in 1973 (fig. 33).

Exports of lumber, chiefly softwoods, have roughly tripled since the early 1950's, rising from

Exports of softwood logs, pulp products, and lumber have been rising.

[4] "Roundwood equivalent" represents the volume of logs or other round products (roundwood) required to produce the woodpulp, paper, plywood, or other processed materials imported. It is recognized that portions of imports (and exports) of products such as woodpulp are produced from plant residues and thus do not directly represent roundwood use. Roundwood equivalent data do indicate relative volumes of traded products and a measure of trade that is comparable to the estimates of demand presented above.

0.1 billion cubic feet roundwood equivalent (0.5 billion board feet) to 0.3 billion cubic feet in 1973 (2 billion board feet). Most of the increased shipments in recent years have gone to Japan, with smaller amounts to Europe, Latin America, and other countries.

Exports of pulp products also grew rapidly in the 1950–73 period moving up from less than 0.1 to 0.6 billion cubic feet, roundwood equivalent. The bulk of this increase has been in the form of pulp and liner board shipped to Western Europe and to the Far East, principally to Japan.

Pulp chips produced from slabs and other residues of primary timber processing plants on the Pacific Coast have made up a growing part of the shipments of pulp products to Japan since the mid-1960's. Small volumes of roundwood pulpwood have been exported to Canada for some time.

The volume of logs exported has also increased rapidly since the early 1950's rising from 5 million to over 500 million cubic feet in 1973 (3.3 billion board feet local log scale). By far the largest part of these exports consisted of softwood logs (3.1 billion board feet in 1973), with nearly 90 percent of these going to Japan.

Exports of items such as plywood and veneer, poles, piling, etc. have grown, but the volumes involved have represented a very small part of the harvest of roundwood from U.S. forests.

Future trends in U.S. imports and exports of timber products will largely depend on the economic availability of timber in the major forested regions of the world, and on the timber demand-supply-price situation in the major consuming areas. The timber situation in Canada (the source of most U.S. imports), and to a lesser extent in the tropical hardwood areas, is of primary importance in appraising future prospects. Demand in western Europe and Japan is of particular significance in estimating export trends.

Trends in World Timber Demands

Consumption of industrial timber products has been growing rapidly in all parts of the world, rising some 70 percent between 1950 and 1969. Projections prepared by the Food and Agriculture Organization of the United Nations and other organizations point to substantial increases in demands in the decades ahead.[5]

The situation in Europe.—In 1970, an estimated 11.9 billion cubic feet of industrial wood—about a quarter of world production—was consumed in Europe, excluding the Soviet Union. Projections of the Economic Commission for Europe indicate that this upward trend is likely to continue with the expansion of European economies. Projected demands for industrial timber products increase by about 27 percent between 1970 and 1980, and roughly double by 2000. Most growth is for pulp and paper products and wood-based panels. Demand for sawnwood (lumber) are projected to grow only a little faster than population, while demands for miscellaneous roundwood decline.

Studies of the prospective European timber supply situation indicate that timber supplies from European forests could be expanded. However, the increase in supplies is much below the anticipated growth in demands. As a result, timber deficits are projected to amount to 2.3 billion cubic feet by 1980, some 60 percent above 1970. Longer run assessments indicate that by 2000, the deficit may be somewhere between 4.2 and 7.9 billion cubic feet.

This outlook suggests continuing increases in European demands for pulp and paper products produced in the United States. In the case of lumber and logs, however, it seems likely that most of the growth will be supplied by imports from the Soviet Union, Canada, and tropical hardwood regions.

The situation in Japan.—The phenomenal economic growth of Japan in the last couple of decades has resulted in a sixfold increase in industrial wood consumption between 1950 and 1972 to 3.6 billion cubic feet, roundwood equivalent.

Although Japan is heavily forested, its timber resources are relatively limited in relation to population. Japanese forests were also severely depleted by heavy cutting during World War II. To meet rapidly increasing demands, imports of logs and other products into Japan have increased sharply, and in 1972 amounted to 2 billion cubic feet—56 percent of total supplies.

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[5] Examples of relevant studies include: Algvere, Karl Viktor. Forest economy in the USSR. Studia Forestalia Suecica, No. 39, Royal College of Forestry, Stockholm, Sweden. 1966.

Food and Agriculture Organization of the United Nations. Wood: World trends and prospects. FFHC Basic Study 16, 131 p. Rome. 1967.

Algvere, Karl Viktor. Outlook for pulp and paper consumption, production and trade to 1985. Second Consultation on World Pulp and Paper Demand, Supply and Trade. Rome 1971.

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United Nations Center for Housing, Building and Planning. Housing needs, trends and prospects. Unasylva Vol. 25 (2–3–4), nos. 101–102–103, p. 7–25. 1971.

United Nations Economic and Social Council, Economic Commission for Europe Timber Committee. TIM/Working Paper No. 173/Add. 1, 19 p. July 12, 1972.

For many years, imports were mainly tropical hardwood logs for use in production of plywood, but since the early 1960's, imports of softwood logs for the manufacture of lumber, and imports of chips for pulp manufacture, have risen sharply. Most of the softwood log imports have originated in the United States and the Soviet Union. By far the largest part of the pulp chip imports have come from the United States. Canada and the United States have also supplied most of the growing amounts of pulp and paper imports.

Estimates of the Japanese Forestry Agency indicate that demand for timber products will continue to grow rapidly to an estimated 4.8 billion cubic feet by 1981. Imports are expected to play an increasingly important role, rising to about 3 billion cubic feet by 1981, or 63 percent of total projected demands.

Beyond the early 1980's Japanese forests are expected to be capable of supplying an increasing share of total demands. But this outlook could be changed by shortfalls in forestry programs, diversions of forest land to other uses, or constraints on timber production associated with protection of the environment. In any event, it seems clear that Japan is likely to continue to be a major importer of timber products from North America, Siberia, Southeast Asia, and perhaps other areas during the next few decades.

The situation in other countries and regions.—Although most of the U.S. export trade in timber products has been with Europe and Japan, there have been significant exports of woodpulp, paper and board, lumber, logs, veneer, and plywood to Canada and other countries of the world. These exports have been rising slowly, and this trend is expected to continue through the projection period.

World Forest Resources

A large part of the forest resources of the world has never been surveyed, and the available data on forest areas and timber volumes undoubtedly contain substantial errors of estimate. Nonetheless, it seems apparent that these resources are extensive.

Forests cover an estimated 9.2 billion acres, or about 28 percent of the world's land area. About two-thirds of this area is hardwood forests and one-third softwood. Most of the hardwood forests are in Latin America and the tropical regions of Africa and Southeast Asia. The softwood acreage is concentrated in the USSR (1,366 million acres) and in North America (1,087 million acres), with only 525 million acres in all other countries.

The world's forests contain an estimated 12.6 trillion cubic feet of timber (table 65). Softwoods make up one-third of this timber inventory. North America and the USSR contain the largest volumes of softwood growing stock, while Latin America, Africa, and Southeast Asia have most of the hardwood volumes.

Table 65. *Forest growing stock in the world, by area and species group*

(*Billion cubic feet*)

Area	Total	Softwoods	Hardwoods
North America	2,083	1,395	689
Latin America	4,340	99	4,241
Europe	473	290	184
Africa	1,232	11	1,222
Asia (except Japan and U.S.S.R.)	1,444	212	1,232
Japan	67	35	32
USSR	2,807	2,345	463
Pacific Area	177	11	166
World	12,623	4,396	8,227

Source: Food and Agriculture Organization of the United Nations. *Supply of wood materials for housing.* World Consultation on the Use of Wood Housing, Secretariat Pap., Sect. 2. 1971.

In the late 1960's, the total world harvest of industrial roundwood was about 42 billion cubic feet, about three-fourths of this volume from softwood forests in North America, the USSR and Europe.

About two-thirds of the hardwood timber came from the forests of North America, Asia, and Europe—even though these areas contain only 25 percent of the world's hardwood growing stock inventory. Latin America contains over half the total world hardwood resources, but has accounted for less than 10 percent of world production of hardwood products in the late 1960's.

Timber supply potential.—Hardwood forests in many regions of the world, including the United States, could support higher levels of harvest in the next several decades. Most of this potential is in the hardwood forests of Latin America, Southeast Asia, and Africa.

The tropical hardwood forests are extensive and have a large capacity for timber growing, but there are serious problems which offset the capability of these forests to continue to supply high-quality timber products to world markets. For example, much of the tropical forest area is relatively inaccessible, and development of timber resources is slow and expensive. Utilization of timber is also complicated by the great numbers of species of widely different characteristics. In just one Amazon type, for example, 50 percent of the volume was found to be in 35 species, with the other 50 percent in more than 100 additional species. Such problems of heterogeneity are less severe in Africa and least in southeast Asia, but occur in all regions. The future of tropical forests in all regions is also further complicated by the

The world's tropical hardwood forests can support higher levels of harvest.

expanding need for agricultural land to accommodate rapidly growing populations, and the difficulties involved in managing many tropical soils.

Prospects for significant additions to softwood timber production, and exports from existing but unutilized resources, seem limited to the northern parts of Canada and Siberia. Both Canada and the USSR have indicated a desire to develop their forest resources. Unused timber in both countries is under government control, and hence government policies—as well as trends in prices, markets, and availability of investment capital—will be significant factors in determining how rapidly expansion of timber output takes place.

The softwood timber resources of Canada are of special significance to the United States, for both geographic and economic ties make Canada a primary timber supply region for this country. Canada is the leading timber exporting nation in the world, with three-fourths of her exports going to the United States.

The 1970 Canadian timber cut of about 4.3 billion cubic feet (3.9 billion softwoods) was well below the calculated sustainable allowable cut of 10.7 billion cubic feet (8.2 billion softwoods). Most of the unused timber is in the undeveloped northern parts of the Canadian provinces where utilization will necessarily involve high development costs. Thus it appears unlikely that a significant portion of the unused allowable cut would be placed on the market at 1970 prices. However, with June 1972 cost-price relationships for lumber and plywood, and somewhat higher prices for pulp and paper, the British Columbia Council of the Forest Industries has estimated that about 8 billion cubic feet of allowable cut would be economically available.

These and related projections of the Canadian Forestry Service indicated that, by 2000, production of lumber, pulp, paper, and plywood could be materially increased over 1970 levels. These Canadian studies also show that exports to the United States could be increased substantially.

Prospective Trends in U.S. Timber Product Trade

The available data on prospective increases in the demand for industrial roundwood products in the major consuming countries and regions of the world suggest continuing growth in markets for U.S. products. Accordingly, it has been assumed that exports would rise (tables 66 and 67), with most of the increase in the form of kraft pulp and paper products.

Table 66. *Summary of roundwood consumption, exports, imports, and production from U.S. forests 1952, 1962, and 1970, with projections (medium level[1]) under alternative price assumptions to 2020*

(Billion cubic feet, roundwood equivalent)

Year	All species				Softwoods				Hardwoods			
	U.S. consumption	Exports	Imports	Production from U.S. forests[2]	U.S. consumption	Exports	Imports	Production from U.S. forests[2]	U.S. consumption	Exports	Imports	Production from U.S. forests[2]
1952	11.9	0.2	1.4	10.8	8.4	0.2	1.3	7.3	3.5	(3)	0.1	3.5
1962	11.6	.5	1.9	10.2	8.5	0.4	1.7	7.2	3.1	0.1	.2	3.0
1970	12.7	1.4	2.4	11.7	9.7	1.2	2.1	8.8	3.0	.2	.3	2.9
1970 relative prices												
Year	U.S. demand	Exports	Imports	Demand on U.S. forests	U.S. demand	Exports	Imports	Demand on U.S. forests	U.S. demand	Exports	Imports	Demand on U.S. forests
1980	16.6	2.3	2.8	16.1	12.3	2.0	2.4	11.9	4.3	.3	.4	4.2
1990	19.2	2.4	3.0	18.6	13.8	2.1	2.5	13.4	5.4	.3	.5	5.2
2000	22.0	2.4	3.1	21.3	15.4	2.1	2.6	14.9	6.6	.3	.5	6.4
2010	25.1	2.6	3.1	24.6	17.2	2.2	2.6	16.8	7.9	.4	.5	7.8
2020	27.8	2.6	3.1	27.3	18.8	2.2	2.6	18.4	9.0	.4	.5	8.9
Rising relative prices[4]												
1980	15.2	2.3	3.7	13.8	11.3	2.0	3.2	10.1	3.9	.3	.5	3.7
1990	16.6	2.4	4.4	14.6	12.1	2.1	4.9	10.3	4.5	.3	.5	4.3
2000	18.2	2.5	5.0	15.7	12.8	2.2	4.3	10.7	5.4	.3	.7	5.0
2010	20.1	2.6	5.2	17.5	13.9	2.2	4.4	11.7	6.2	.4	.8	5.8
2020	22.1	2.6	5.4	19.3	14.8	2.2	4.6	12.4	7.3	.4	.8	6.9
Relative prices above 1970 averages[5]												
1980	14.6	2.3	3.9	13.0	10.7	2.0	3.3	9.4	3.9	.3	.6	3.6
1990	17.2	2.4	4.4	15.2	12.4	2.1	3.8	10.7	4.8	.3	.6	4.5
2000	19.6	2.5	4.5	17.6	13.7	2.2	3.9	12.0	5.9	.3	.6	5.6
2010	22.6	2.6	4.5	20.7	15.6	2.2	3.9	13.9	7.0	.4	.6	6.8
2020	25.4	2.6	4.5	23.5	17.2	2.2	3.9	15.5	8.2	.4	.6	8.0

[1] Based on the medium projections of growth in population and economic activity shown in the section on basic assumptions.

[2] The data for 1952, 1962, and 1970 are estimates of actual harvests and are not directly comparable with the trend level estimates of supply shown in tables 75 and 76.

[3] Less than 50 million cubic feet.

[4] Relative prices rising from 1970 trend level as follows: lumber—1.5 percent per year; plywood, miscellaneous products, and fuelwood—1.0 percent per year; paper and board—0.5 percent per year.

[5] Relative prices of lumber and plywood—30 percent, miscellaneous products and fuelwood—15 percent, and paper and board—10 percent above the 1970 averages.

Note: Columns may not add to totals because of rounding.

Sources: 1952–70—Based on data published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

Table 67. *Summary of sawtimber consumption, exports, imports, and production from U.S. forests, 1952, 1962, and 1970, with projections (medium level[1]) under alternative price assumptions to 2020*

(Billion board feet, International 1/4-inch log rule)

Year	All species				Softwoods				Hardwoods			
	U.S. consumption	Exports	Imports	Production from U.S. forests[2]	U.S. consumption	Exports	Imports	Production from U.S. forests[2]	U.S. consumption	Exports	Imports	Production from U.S. forests[2]
1952	51.6	0.7	2.7	49.6	39.9	0.7	2.4	38.2	11.6	0.2	0.3	11.5
1962	53.3	1.4	5.6	49.1	41.7	1.2	4.6	38.3	11.7	.2	1.0	10.9
1970	59.9	4.7	7.3	57.3	47.6	4.6	5.9	46.2	12.3	.2	1.3	11.2
1970 relative prices												
Year	U.S. demand	Exports	Imports	Demand on U.S. forests	U.S. demand	Exports	Imports	Demand on U.S. forests	U.S. demand	Exports	Imports	Demand on U.S. forests
1980	76.0	7.2	8.6	74.6	59.3	6.9	6.6	59.6	16.7	.3	2.0	15.0
1990	84.0	7.8	8.5	83.3	64.0	7.5	6.5	65.0	20.0	.3	2.0	18.3
2000	91.2	8.4	8.4	91.2	68.1	8.1	6.4	69.8	23.1	.3	2.0	21.4
2010	100.3	8.6	8.3	100.6	73.3	8.3	6.3	75.3	27.0	.3	2.0	25.3
2020	108.6	8.5	8.2	108.9	77.7	8.2	6.2	79.7	30.9	.3	2.0	29.2
Rising relative prices[3]												
1980	67.3	7.2	10.9	63.6	52.4	6.9	8.9	50.4	14.9	.3	2.0	13.2
1990	68.7	7.7	13.2	63.2	52.3	7.4	10.8	48.9	16.4	.3	2.4	14.3
2000	68.9	8.3	14.1	63.1	50.9	8.0	11.4	47.5	18.0	.3	2.7	15.6
2010	70.6	8.5	14.4	64.7	50.7	8.2	11.6	47.3	19.9	.3	2.8	17.4
2020	71.8	8.4	14.7	65.6	50.2	8.1	11.8	46.5	21.6	.3	2.9	19.0
Relative prices above 1970 averages[4]												
1980	63.5	7.1	12.0	58.6	49.2	6.8	9.6	46.4	14.3	.3	2.4	12.2
1990	70.9	7.7	13.2	65.4	53.8	7.4	10.8	50.4	17.1	.3	2.4	15.0
2000	77.6	8.4	13.1	72.9	57.6	8.1	10.7	55.0	20.0	.3	2.4	17.9
2010	86.0	8.5	13.0	81.5	62.4	8.2	10.6	60.0	23.6	.3	2.4	21.5
2020	93.4	8.5	12.9	89.0	66.3	8.2	10.5	64.0	27.1	.3	2.4	25.0

1 Based on the medium projections of growth in population and economic activity shown in the section on basic assumptions.

2 The data for 1952, 1962, and 1970 are estimates of actual harvests and are not directly comparable with the trend level estimates of supply shown in tables 76 and 78.

3 Relative prices rising from 1970 trend level as follows: lumber—1.5 percent per year; plywood, miscellaneous products, and fuelwood—1.0 percent per year; paper and board—0.5 percent per year.

4 Relative prices of lumber and plywood—30 percent, miscellaneous products and fuelwood—15 percent, and paper and board—10 percent, above the 1970 averages.

Note: Columns may not add to totals because of rounding.

Sources: 1952–70—Based on data published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service

In spite of growing world demands for timber products, it has also been assumed that potentials for increased harvests, especially in Canada and the tropical hardwood regions, are sufficient to provide a significant expansion of U.S. imports of timber products (tables 66 and 67).

The largest increases in imports are expected in lumber and pulp and paper products from Canada. It also seems likely that the United States will draw somewhat more heavily on tropical forests for hardwood plywood and veneer for some time to come in spite of the uncertainties surrounding the long-term outlook.

Since a large part of the available timber resources of the world is in areas where utilization will involve high development costs, projected imports are likely to be substantially greater under the higher price assumptions. Thus, projections of net imports under the higher price assumptions rise over the projection period and offer a partial solution to timber demand-supply problems.

Demand for Timber from U.S. Forests

As indicated above, improvements in utilization and increases in net imports can meet part of the projected growth in demand for timber products. However, these potentials are relatively small in comparison to the total growth in demand at something approaching relative price stability. Thus, the Nation must look to its domestic timber resources as the best means of attaining some stability in relative prices of timber products.

Production of softwood roundwood from U.S. forests showed little change in the 1950's but a fairly fast increase in the 1960's (table 66). Production of softwood sawtimber from U.S. forests followed similar trends (table 67). In contrast, production of hardwoods—roundwood and sawtimber—showed a slight downward trend during both decades.

Projected demand for timber from U.S. forests—medium level and 1970 prices—rises from 11.7 billion cubic feet in 1970 to 27.3 billion cubic feet by 2020—an increase of 133 percent. Associated demands for sawtimber rise from 57.3 to 108.9 billion board feet. Most of the projected expansion in sawtimber demand is for softwoods. However, demand for hardwoods exhibits a larger percentage growth—some 160 percent by 2020.

As in the case of total demand, use of alternative economic and price assumptions has substantial impacts on projected demands for timber from U.S. forests. With relative prices 30 percent above the 1970 averages, for example, projected demand on U.S. forests in 2020 is 23.5 billion cubic feet, including 89.0 billion board feet of sawtimber. These volumes are 101 percent and 55 percent, respectively, above 1970 production levels.

Because of differences in the size of the assumed price increases by product, and the sensitivity of demand for each product to rising relative prices, the impact of higher prices is primarily on demands for sawtimber products. For example, under the rising price assumption (1.5 percent per year for lumber; 1.0 percent for plywood, miscellaneous products, and fuelwood; and 0.5 percent for paper and board) demands for domestic sawtimber in 2020 would be 65.6 billion board feet—14.5 percent above production in 1970. In contrast, projected demands for softwood roundwood rise by about 41 percent, largely because of increases in demand for pulpwood.

Although there are differences in the magnitudes of the increases, all projections indicate substantially larger demands on domestic forests.

U.S. Timber Resources and Supplies

Commercial Timberland

The United States has large timber resources. As shown in the introductory section of this study (table 1) about 500 million acres—22 percent of the Nation's land area—is classified as commercial timberland.

Nearly three-quarters of the commercial timberland is located in the eastern half of the United States, about equally divided between the North and South sections (table 68). The one-quarter of the Nation's commercial timberland located in the West is concentrated in the Pacific Coast States of Oregon, Washington, and California, and in the Rocky Mountain States of Montana, Idaho, and Colorado.

Largely as a result of historical policies which encourage transfer of public domain lands to private ownership, about 73 percent of all commercial timberland was privately owned in 1970. Twenty-seven percent was in Federal, State, and other public holdings (table 68).

Over half of the commercial timberland is occupied by hardwood species such as oaks, hickory, gum, maple, birch, and aspen. Another 42 percent is occupied by the southern pines, Douglas-fir, hemlock, spruce, and other softwood species.

Timber Inventory

The commercial timberlands of the United States contained some 715 billion cubic feet of sound wood in 1970 (table 69).

Size and species of timber.—About 64 percent of this total volume was in sawtimber trees (trees large enough to contain at least one log suitable for the manufacture of lumber). Another 27 percent was in

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About 500 million acres—nearly a quarter of the Nation's land area—is classified as commercial timberland.

poletimber trees (trees from 5 inches in diameter at breast height to sawtimber size and now or prospectively suitable for industrial roundwood). The remaining 9 percent of all sound wood volume was in rough and rotten trees and salvable dead trees. Some of this latter material is suitable for lumber and veneer, but most of it is usable only for pulp and other products where log quality requirements are more flexible.

Softwoods predominate in the Nation's timber inventory, accounting for about 64 percent of the total volume of all classes of timber, and over three-fourths of the total sawtimber volume. These softwood inventories are mostly on the Pacific Coast (table 70). This distribution, in contrast to that for commercial timberland, which is mostly in the East, reflects the concentration of timber in western old-growth stands with relatively high volumes per acre.

Hardwoods made up about 36 percent of all classes of standing timber in 1970, and about 25 percent of all sawtimber. More than half of all hardwood growing stock was in the North.

Ownership of timber.—The largest portion of the softwood timber inventory in 1970 was in National Forests, including some 46 percent of all softwood growing stock and 51 percent of all softwood sawtimber (table 71). Most of this timber was in old-growth stands in the West, with a major part in areas still lacking access roads. Only 8 percent of all hardwood growing stock was in National Forests.

Farm and miscellaneous private ownerships contained the major part of the Nation's inventory of hardwoods—about 71 percent—and a substantial part of all softwood inventories—about 26 percent. Nearly all of this timber is readily accessible from

Table 68. *Area of commercial timberland in the United States, by type of ownership and section, January 1, 1970*

Type of Ownership	Total United States		North	South	Rocky Mountains	Pacific Coast
	Area	Proportion				
Federal:	*Thousand acres*	*Percent*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
National Forest	91,924	18	10,458	10,764	[2]39,787	30,915
Bureau of Land Management	4,762	1	75	11	2,024	2,652
Bureau of Indian Affairs[1]	5,888	1	815	220	2,809	2,044
Other Federal	4,534	1	963	3,282	78	211
Total Federal	107,109	21	12,311	14,277	44,699	35,822
State	21,423	4	13,076	2,321	2,198	3,828
County and municipal	7,589	2	6,525	681	71	312
Forest industry	67,341	14	17,563	35,325	2,234	12,219
Farm	131,135	26	51,017	65,137	8,379	6,602
Miscellaneous private	165,101	33	77,409	74,801	4,051	8,840
All ownerships	499,697	100	177,901	192,542	61,632	67,623

[1] Lands held in common by Indian Tribal Groups.

[2] Includes 5 million acres classified as "unregulated" commercial timberland.

Source: U.S. Department of Agriculture, Forest Service. *The outlook for timber in the United States.* Forest Resource Rep. 20, 367 p. 1973.

Table 69. *Timber inventories on commercial timberlands in the United States, by class of material and species group, 1970*

Class of timber	All species		Softwoods			Hardwoods
	Volume	Proportion	Total	Eastern	Western	
Sawtimber trees:	*Million cu. ft.*	*Percent*	*Million cu. ft.*	*Million cu. ft.*	*Million cu. ft.*	*Million cu. ft.*
Saw-log portions	[1]410,774	57.5	317,280	66,219	251,062	93,493
Upper stems	44,602	6.2	23,753	10,039	13,714	20,849
Total	455,376	63.7	341,033	76,258	264,776	114,342
Poletimber trees	193,504	27.1	90,840	41,261	49,579	102,664
Total growing stock	648,879	90.8	431,874	117,519	314,355	217,005
Salvable dead trees	12,035	1.7	11,361	173	11,189	673
Sound cull trees	33,921	4.7	6,910	3,773	3,138	27,010
Rotten cull trees	19,711	2.8	5,022	1,281	3,742	14,689
All classes	[2]714,546	100.0	455,168	122,746	332,423	259,378

[1] This portion is also expressed in board feet of sawtimber, i.e., 2,420,767 million board feet, or an average of 5.9 board feet per cubic foot of the saw-log portion.

[2] Additional timber volumes not inventoried by the Forest Survey, but providing some timber products, include wood in limbs and stumps, trees on noncommercial forest lands, and trees on other areas such as parks and fence rows.

Note: Columns may not add to totals because of rounding.

Source: *The outlook for timber in the United States*, op. cit.

existing road systems and is relatively close to timber markets.

Forest industries held about 17 percent of all softwood inventories in 1970, and a somewhat smaller proportion of hardwoods. Wood-using plants in the East thus must look to nonindustrial private ownerships for much of their timber supply, while many western firms must depend on National Forest and other public lands for much of their log requirements.

Public ownerships other than National Forests held roughly 10 percent of all timber inventories in 1970. These inventories were of particular importance in the Pacific Northwest and the Lake States.

Timber Mortality

Annual mortality losses from natural causes—fire, insects, disease, storms, and other destructive agents—were estimated at about 4.5 billion cubic

Table 70. *Growing stock and sawtimber inventories on commercial timberlands in the United States, by section and softwoods and hardwoods, 1970*

GROWING STOCK

Section	All species		Softwoods		Hardwoods	
	Volume	Proportion	Volume	Proportion	Volume	Proportion
	Billion cu. ft.	*Percent*	*Billion cu. ft.*	*Percent*	*Billion cu. ft.*	*Percent*
North	155.7	24.0	39.1	9.0	116.6	53.7
South	159.5	24.6	78.4	18.2	81.1	37.4
Rocky Mountains	92.2	14.2	87.7	20.3	4.5	2.1
Pacific Coast	241.5	37.2	226.6	52.5	14.8	6.8
Total	648.9	100.0	431.9	100.0	217.0	100.0

SAWTIMBER

	Billion bd. ft.	*Percent*	*Billion bd. ft.*	*Percent*	*Billion bd. ft.*	*Percent*
North	331.9	13.7	80.1	4.2	251.8	48.8
South	483.9	20.0	275.9	14.5	208.0	40.4
Rocky Mountains	364.4	15.1	355.1	18.6	9.3	1.8
Pacific Coast	1,240.6	51.2	1,194.2	62.7	46.4	9.0
Total	2,420.8	100.0	1,905.3	100.0	515.5	100.0

Note: Columns may not add to totals because of rounding.

Source: *The outlook for timber in the United States*, op. cit.

Table 71. *Ownership of growing stock and sawtimber in the United States, by softwoods and hardwoods, January 1, 1970*

GROWING STOCK

Type of ownership	Total		Softwoods		Hardwoods	
	Volume	Proportion	Volume	Proportion	Volume	Proportion
	Billion cu. ft.	*Percent*	*Billion cu. ft.*	*Percent*	*Billion cu. ft.*	*Percent*
National Forest	217	34	200	46	18	8
Other public	68	10	48	11	20	9
Forest industry	100	15	73	17	27	12
Farm and miscellaneous private	264	41	110	26	153	71
All ownerships	649	100	432	100	217	100

SAWTIMBER

	Billion bd. ft.	*Percent*	*Billion bd. ft.*	*Percent*	*Billion bd. ft.*	*Percent*
National Forest	1,022	42	982	51	40	8
Other public	263	11	223	12	40	8
Forest industry	386	16	318	17	68	13
Farm and miscellaneous private	751	31	382	20	368	71
All ownerships	2,421	100	1,905	100	515	100

Note: Data may not add to totals because of rounding.

Source: *The outlook for timber in the United States*, op. cit.

feet of growing stock in 1970. Mortality of sawtimber amounted to an estimated 15.3 billion board feet (that is, roughly 2.6 billion cubic feet in the saw-log portion of sawtimber trees). About three-fifths of growing stock mortality and three-quarters of sawtimber mortality was in softwood species.

Most softwood mortality in 1970 was in the West, chiefly in the Pacific Coast section. This distribution

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Wildfire is an important cause of mortality in U.S. forests.

is related to the concentration of timber volumes in the West, and the high proportion of overmature timber in old-growth stands. Much of the sawtimber lost included trees containing large proportions of high-quality materials. But most mortality occurred in inaccessible and unroaded areas, especially on the National Forests, where salvage has not been feasible.

Net Annual Timber Growth

Recent trends in net annual growth (i.e., total annual growth less mortality) of timber illustrates a success story in American forestry. In response to programs of forest fire control, tree planting, and other forestry measures, net annual growth of softwoods and hardwoods combined increased 18 percent between 1952 and 1962, and a further 14 percent between 1962 and 1970 (table 72). This upward trend occurred in both softwoods and hardwoods, and for both sawtimber and all growing stock (table 73).

Net growth has been rising in all regions, although softwood sawtimber in the South and hardwood sawtimber in the North showed the largest increases. There is, of course, considerably more commercial timberland in the East than in the West, and eastern stands are essentially all young growth where mortality is relatively low. In the West, sizeable areas still support old-growth in which mortality nullifies much of the total growth.

In spite of recent substantial increases, net growth of timber is still much less than potential yields in fully stocked natural stands (table 74). Even higher yields are attainable in stands under intensive management with use of genetically improved trees, fertilization, and spacing control.

Table 72. *Net annual growth and removals of growing stock in the United States, by species group and section*[1]

(*Billion cubic feet*)

Section	All species			Softwoods			Hardwoods		
	1952	1962	1970	1952	1962	1970	1952	1962	1970
North:									
Net growth	4.1	4.9	5.5	1.1	1.2	1.4	3.0	3.6	4.2
Removals	2.1	2.1	2.4	.6	.6	.6	1.5	1.5	1.8
Ratio of growth to removals	2.0	2.4	2.3	1.7	2.2	2.2	2.1	2.4	2.3
South:									
Net growth	6.3	7.5	8.6	3.6	4.5	5.4	2.7	3.0	3.2
Removals	5.7	5.4	6.5	3.1	2.8	4.0	2.6	2.6	2.5
Ratio of growth to removals	1.1	1.4	1.3	1.2	1.6	1.4	1.1	1.1	1.3
Rocky Mountains:									
Net growth	1.2	1.3	1.4	1.1	1.2	1.3	.1	.1	.1
Removals	.5	.7	.9	.5	.7	.9	(2)	(2)	(2)
Ratio of growth to removals	2.2	1.8	1.5	2.1	1.7	1.4	21.9	18.9	26.2
Pacific Coast:									
Net growth	2.3	2.7	3.1	2.0	2.3	2.6	.3	.4	.5
Removals	3.5	3.6	4.2	3.5	3.5	4.1	(2)	.1	.1
Ratio of growth to removals	.7	.8	.7	.6	.7	.6	6.7	4.9	4.1
Total, United States:									
Net growth	13.9	16.4	18.6	7.8	9.3	10.7	6.1	7.1	7.9
Removals	11.8	11.8	14.0	7.8	7.6	9.6	4.1	4.2	4.4
Ratio of growth to removals	1.2	1.4	1.3	1.0	1.2	1.1	1.5	1.7	1.8

[1] Columns may not add to totals because of rounding. Ratios calculated from growth-removal data before rounding.

[2] Less than 0.05 billion.

Note: Data for 1952 and 1962 differ from data published in earlier reports because of adjustments based on newer information from remeasured Forest Survey plots. Data for all years are "trend level" estimates.

Source: *The outlook for timber in the United States*, op. cit.

Table 73. *Net annual growth and removals of sawtimber in the United States, by species group and section*[1]

(*Billion board feet*)

Section	All species			Softwoods			Hardwoods		
	1952	1962	1970	1952	1962	1970	1952	1962	1970
North:									
Net growth	9.4	11.5	13.7	2.4	2.8	3.6	7.0	8.6	10.1
Removals	6.7	6.5	9.0	1.9	1.5	2.1	4.8	5.0	6.8
Ratio of growth to removals	1.4	1.8	1.5	1.3	1.9	1.7	1.4	1.7	1.5
South:									
Net growth	21.2	24.3	28.0	13.6	16.7	20.1	7.6	7.6	7.9
Removals	20.2	17.2	22.8	11.9	9.8	15.0	8.3	7.3	7.8
Ratio of growth to removals	1.1	1.4	1.2	1.1	1.7	1.3	.9	1.0	1.0
Rocky Mountains:									
Net growth	4.3	4.6	5.1	4.2	4.5	4.9	.1	.1	.1
Removals	3.2	4.3	5.4	3.2	4.3	5.4	([2])	([2])	([2])
Ratio of growth to removals	1.3	1.1	.9	1.3	1.1	.9	6.3	5.4	11.7
Pacific Coast:									
Net growth	10.3	11.9	13.1	9.4	10.7	11.6	.9	1.2	1.5
Removals	22.4	22.3	25.6	22.3	22.1	25.2	.1	.2	.4
Ratio of growth to removals	.5	.5	.5	.4	.5	.5	6.2	5.0	4.0
Total, United States:									
Net growth	45.1	52.3	59.9	29.5	34.7	40.3	15.6	17.6	19.7
Removals	52.5	50.3	62.8	39.2	37.7	47.7	13.3	12.6	15.0
Ratio of growth to removals	.9	1.0	1.0	.8	.9	.8	1.2	1.4	1.3

[1] Columns may not add to totals because of rounding.

[2] Less than 0.05 billion.

Note: Data for 1952 and 1962 differ from data published in earlier reports because of adjustments based on newer information from remeasured Forest Survey plots. Data for all years are "trend level" estimates.

Source: *The outlook for timber in the United States*, op. cit.

Table 74. *Average net annual and potential growth per acre in the United States, by owner, class, and section, 1970*[1]

(*Cubic feet*)

Section	All owners	National Forest	Other public	Forest industry	Farm and miscellaneous private
North:					
Current	31	38	33	40	29
Potential	68	66	59	72	69
South:					
Current	45	55	45	53	42
Potential	76	70	71	81	75
Rocky Mountains:					
Current	24	23	23	47	25
Potential	60	65	54	70	50
Pacific Coast:					
Current	45	27	60	65	58
Potential	95	88	100	107	96
Total:					
Current	38	30	39	52	36
Potential	74	73	68	83	72

[1] Potential growth is defined as the average net growth attainable in fully stocked natural stands. Higher growth rates can be attained in intensively managed stands.

Source: *The outlook for timber in the United States*, op. cit.

The relatively limited net growth of growing stock and sawtimber in relation to potentials in 1970, in part, reflected partial stocking of trees on much of the forest area, mortality and growth losses from destructive agents, and the presence of brush and cull trees which limit regeneration and increment of growing stock trees. These and other factors, such as restocking problems, often make it difficult and costly to achieve "full" stocking.

In old-growth stands in the West, mortality offsets much of the total growth and contributes to the relatively low net annual growth per acre, particularly on western National Forests.

Timber Removals

Timber removals[6] in 1970 totaled about 14 billion cubic feet of growing stock, including 62.8 billion board feet of sawtimber (tables 72 and 73). These volumes were substantially above levels in the 1950's and early 1960's, when removals averaged about 12 billion cubic feet, including 50 billion board feet of sawtimber.

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About 14 billion cubic feet of wood is removed from U.S. forests each year. By far, the largest portion of this is used in the manufacture of lumber, woodpulp, and other products.

Softwoods made up some two-thirds of all growing stock removals, and three-quarters of all sawtimber removals in 1970. These removals were concentrated in the Pacific Coast and South.

About a third of all softwood removals in 1970 came from forest industry ownerships. Nearly 40 percent from farm and miscellaneous private ownerships, and about 30 percent from public lands.

By far the largest portion of the timber removed is used for timber products. In 1970, 87 percent of all softwood removals and 63 percent of all hardwood removals were used in this way. Total product use amounted to 11.1 billion cubic feet of roundwood, including 54.7 billion board feet of sawtimber. Logging residues composed most of the remaining removals.

Timber Growth-Removal Balances

Comparisons of net annual growth and removals provide one important indicator of the present timber situation including the physical availability of timber for harvest.[7]

Softwoods.—In the past two decades, net annual growth of softwoods in the eastern sections of the United States has been considerably higher than removals (table 72). Thus in 1970, net growth of eastern softwoods exceeded removals by 2.2 billion cubic feet, or 48 percent. Growth of softwood sawtimber in the East exceeded removals by 6.6 billion board feet, or 39 percent (table 73). Most of the excess of growth over removals was in the South.

These generally favorable growth-removal balances indicate that eastern forests, and especially those in the South, can support larger softwood timber harvests. However, large areas are still understocked and a growth surplus will be needed for some time if inventories are to be built up to more desirable levels. Also, some part of the growth is on land held primarily for recreation or other nontimber purposes, and thus may not be available for industrial use.

In the West, net growth of softwood growing stock in 1970 was about 3.9 billion cubic feet, 22 percent less than removals. Net growth of softwood sawtimber was some 16.5 billion board feet, or 46 percent less than removals.

These apparent imbalances in the West do not in themselves represent a serious problem for a sizeable part of the western timber harvest is drawn from old-growth stands where allowable harvests can exceed net growth for some time to come. The trend in net growth in the West is rising; but with 1970 levels of management, prospective increases in net growth would not be sufficient to sustain 1970 levels of timber harvest.

Hardwoods.—Net growth of eastern hardwoods in 1970 substantially exceeded removals, particularly in the North (tables 72 and 73). For the entire East, net growth of hardwoods was 7.4 billion cubic feet, or 72 percent greater than removals.

For hardwood sawtimber, net growth was 18.0 billion board feet, 23 percent more than removals. Al-

[6] Timber volumes removed from growing stock inventories on commercial timberland include: (a) harvests of roundwood products such as saw logs, veneer logs, and pulpwood; (b) logging residues; and (c) other removals from changes in land use such as clearing for cropland, highways, or housing developments, and withdrawal of forest lands for parks or other nontimber uses.

[7] Many other factors such as species composition, volumes per acre, accessibility, size of trees, ownership objectives, and prices influence the volume of timber actually available for harvest.

though growth-removal balances for hardwoods were generally favorable, in areas where extensive clearing of bottomlands has occurred—as in the West Gulf region of the South—net growth of hardwoods in 1970 was less than removals.

Utilization of hardwoods is highly oriented to preferred species such as walnut, sweetgum, and yellow birch. Relatively heavy cutting of large diameter trees has also led to a decline in quality of hardwood inventories, and a buildup of smaller diameter trees and nonpreferred species.

Projected Timber Supplies

The current growth-removal balances show that domestic hardwood forests and eastern softwood forests can support additional timber harvests. Future increases will largely depend on the level of forest management, area of land available for commercial timber production, and timber cutting practices and policies. These determinants can vary over a wide range. Nonetheless, supply projections based on the assumptions that (1) recent levels of management will continue, (2) cutting practices and policies will be similar to those of recent years, and (3) the slow downward trend in commercial timberland area will extend through the projection period, provided a base level for judging the future outlook.[8]

Projections of supplies based on these and related assumptions are shown in tables 75–78. These projections show softwood roundwood supplies rising 29 percent between 1970 and 2020, from 9.0 billion to 11.6 billion cubic feet. Projected hardwood supplies increase from 3.2 billion cubic feet in 1970 to 7.4 billion cubic feet by 2020—a rise of 134 percent. Largely as the result of the underlying assumptions, the projected increases are concentrated in the period before 2000.

In the case of sawtimber size material, projected increases in supplies are much more modest. For

[8] For a detailed listing of the assumptions underlying these supply projections, see pages 37–46, *The outlook for timber in the United States*, op. cit.

Table 75. *Roundwood supplies[1] from U.S. forests, by section and species group, 1952, 1962, and 1970, with projections to 2020*

(*Million cubic feet*)

Section and species group	1952	1962	1970	Projections			
				1980	1990	2000	2020
North:							
Softwoods	603	513	579	803	942	1,109	1,113
Hardwoods	1,378	1,299	1,409	2,428	3,165	3,845	3,799
Total	1,981	1,812	1,988	3,231	4,107	4,954	4,912
South:							
Softwoods	3,048	2,677	3,745	4,622	5,217	5,768	5,788
Hardwoods	1,935	1,606	1,668	2,651	3,009	3,327	3,416
Total	4,983	4,283	5,413	7,273	8,226	9,095	9,204
Rocky Mountains:							
Softwoods	495	684	852	1,044	1,139	1,275	1,231
Hardwoods	11	14	11	46	65	89	89
Total	506	698	863	1,090	1,204	1,364	1,320
Pacific Coast:							
Softwoods	3,239	3,324	3,805	3,642	3,376	3,332	3,491
Hardwoods	35	62	85	82	96	105	114
Total	3,274	3,386	3,890	3,724	3,472	3,437	3,605
Total United States:							
Softwoods	7,387	7,199	8,981	10,111	10,675	11,484	11,622
Hardwoods	3,358	2,980	3,173	5,207	6,334	7,365	7,418
Total	10,745	10,179	12,154	15,318	17,009	18,849	19,040

[1] Includes supplies from growing stock and other sources such as rough and rotten trees, dead trees, and trees from noncommercial forest land. Excludes logging residues and nonproduct removals.

Source: *The outlook for timber in the United States*, op. cit.

Table 76. *Sawtimber supplies[1] from U.S. forests, by section and species group, 1952, 1962, and 1970, with projections to 2020*

(*Million board feet*)

Section and species group	1952	1962	1970	Projections			
				1980	1990	2000	2020
North:							
Softwoods	1,898	1,488	2,115	2,390	3,014	3,793	3,793
Hardwoods	4,300	4,430	6,083	7,648	9,997	12,139	11,994
Total	6,198	5,918	8,197	10,038	13,011	15,932	15,787
South:							
Softwoods	11,337	9,292	14,366	17,586	20,882	23,836	23,919
Hardwoods	7,690	6,139	5,914	7,368	7,602	7,752	7,830
Total	19,027	15,431	20,280	24,954	28,484	31,588	31,749
Rocky Mountains:							
Softwoods	3,126	4,189	5,273	5,585	5,648	5,915	5,511
Hardwoods	15	19	13	108	148	195	191
Total	3,141	4,208	5,286	5,693	5,796	6,110	5,702
Pacific Coast:							
Softwoods	22,439	22,540	25,182	23,264	21,323	20,647	20,722
Hardwoods	122	201	322	380	435	469	503
Total	22,561	22,741	25,504	23,644	21,758	21,116	21,225
Total United States:							
Softwoods	38,800	37,510	46,936	48,825	50,867	54,191	53,945
Hardwoods	12,127	10,788	12,331	15,505	18,182	20,556	20,518
Total	50,927	48,298	59,267	64,330	69,049	74,747	74,463

[1] Includes supplies from growing stock and other sources such as rough and rotten trees, dead trees, and trees from noncommercial forest land. Excludes logging residues and nonproduct removals.

Source: *The outlook for timber in the United States*, op. cit.

softwood, the projections rise from 46.9 billion board feet in 1970 to about 54 billion board feet by 2000—an increase of 15 percent. Projected hardwood supplies rise from 12.3 to 20.6 billion board feet. The projections show a small decline in supplies for both species groups after 2000.

Forest industries typically draw much more heavily on larger and better quality sawtimber trees than on other components of the total timber inventory. For example, of the total roundwood produced in 1970, about 80 percent of the softwood products and 65 percent of the hardwood products came from the saw-log portion of sawtimber trees. Consequently, problems of timber supply and price have been, and are likely to continue to be, most critical for products derived from larger sizes of timber.

Supplies by section.—In 1970, the South and the Pacific Coast each supplied about 42 percent of all softwood roundwood. Dependence on the South as a source of softwood roundwood supplies is projected to increase, reaching half the Nation's total supply by 2000. Conversely, the share of U.S. production coming from the West is projected to decline rather sharply as the remaining old-growth timber is harvested.

The South also provided somewhat more than half of the hardwood products harvested in the United States in 1970. Over the next few decades, however, prospectively available supplies of hardwoods increase more in the North than in other sections. In terms of cubic feet, the North consequently accounts for over half the projected supply of hardwood products in 2000 and beyond.

The source of sawtimber supplies is quite different from that of roundwood (table 76). Because of the larger average size of timber, 43 percent of the sawtimber produced in 1970 came from the Pacific Coast section, whereas the South accounted for 34 percent. In the case of roundwood, however, projections show a reversal of this situation, with 43 percent of projected total output in 2020 coming from the South, compared with about 29 percent from the Pacific Coast.

Supplies by owner class.—Farm and miscellaneous

Table 77. *Roundwood supplies[1] from U.S. forests, by owner class and species group, 1952, 1962, and 1970, with projections to 2020*

(Million cubic feet)

Owner class and species group	1952	1962	1970	Projections			
				1980	1990	2000	2020
National Forest:							
Softwoods	838	1,605	1,926	2,309	2,427	2,547	2,551
Hardwoods	60	79	90	210	287	370	378
Total	898	1,684	2,016	2,519	2,714	2,917	2,929
Other public:							
Softwoods	403	547	685	812	943	1,089	1,142
Hardwoods	125	125	149	318	433	548	547
Total	528	672	834	1,130	1,376	1,637	1,689
Forest industry:							
Softwoods	2,700	2,237	2,918	2,759	2,635	2,805	2,993
Hardwoods	486	597	512	619	725	836	902
Total	3,186	2,834	3,430	3,378	3,360	3,641	3,895
Farm and misc. private:							
Softwoods	3,445	2,810	3,451	4,230	4,670	5,043	4,936
Hardwoods	2,688	2,179	2,423	4,061	4,888	5,611	5,592
Total	6,133	4,989	5,874	8,291	9,558	10,654	10,528
Total United States:							
Softwoods	7,387	7,199	8,981	10,111	10,675	11,484	11,622
Hardwoods	3,358	2,980	3,173	5,207	6,334	7,365	7,418
Total	10,745	10,179	12,154	15,318	17,009	18,849	19,040

[1] Includes supplies from growing stock and other sources such as rough and rotten trees, dead trees, and trees from noncommercial forest land. Excludes logging residues and nonproduct removals.

Source: *The outlook for timber in the United States*, op. cit.

private ownerships have long been the principal source of roundwood. Of the 12.2 billion cubic feet of roundwood produced in 1970, nearly half was derived from these sources as shown in table 77 and the tabulation below. About one-fourth of the total came from land owned by forest industries. Public lands also contributed about a quarter of the total.

The distribution of sawtimber harvested shows a heavier concentration of cutting on forest industry and National Forest lands—a result of the relative concentration of larger diameter timber inventories in these holdings (table 78).

The projections indicate that relatively constant proportions of roundwood harvests will be maintained from National Forests and other public owners through 2020. The share of output from forest industry lands is projected to drop about 7 percentage points, with farm and miscellaneous owners sharing a corresponding increase. Nearly all of the decline in supplies from forest industry lands is on

	Percent distribution of roundwood product supplies						
				Projections			
Owner class	*1952*	*1962*	*1970*	*1980*	*1990*	*2000*	*2020*
National Forest	8	16	17	17	16	15	15
Other public	5	7	7	7	8	9	9
Forest industry	30	28	28	22	20	19	21
Farm and miscellaneous private	57	49	48	54	56	57	55
All owners	100	100	100	100	100	100	100

Table 78. *Sawtimber supplies[1] from U.S. forests, by owner class and species group, 1952, 1962, and 1970, with projections to 2020*

(Million board feet)

Owner class and species group	1952	1962	1970	Projections			
				1980	1990	2000	2020
National Forest:							
Softwoods	5,564	10,402	12,548	14,163	14,672	15,228	14,812
Hardwoods	217	332	359	634	910	1,193	1,194
Total	5,781	10,734	12,906	14,797	15,582	16,421	16,006
Other public:							
Softwoods	2,323	3,348	4,236	4,594	5,140	5,790	5,907
Hardwoods	365	339	497	879	1,273	1,679	1,666
Total	2,688	3,687	4,733	5,473	6,413	7,469	7,573
Forest industry:							
Softwoods	16,003	12,964	16,352	14,001	12,896	13,321	13,865
Hardwoods	1,572	1,724	1,774	1,967	2,213	2,456	2,615
Total	17,575	14,688	18,126	15,968	15,109	15,777	16,480
Farm and misc. private:							
Softwoods	14,910	10,796	13,801	16,068	18,158	19,851	19,360
Hardwoods	9,973	8,393	9,701	12,025	13,786	15,228	15,043
Total	24,883	19,189	23,502	28,093	31,944	35,079	34,403
Total United States:							
Softwoods	38,800	37,510	46,936	48,825	50,867	54,191	53,945
Hardwoods	12,127	10,788	12,331	15,505	18,182	20,556	20,518
Total	50,927	48,298	59,267	64,330	69,049	74,747	74,463

[1] Includes supplies from growing stock and other sources such as rough and rotten trees, dead trees, and trees from noncommercial forest land. Excludes logging residues and nonproduct removals.

Source: *The outlook for timber in the United States*, op. cit.

the Pacific Coast—a section where recent harvest levels cannot be sustained given the basic assumptions on area and management underlying the projections.

Timber Demand-Supply Relationships

The projections of timber demands and supplies discussed above are summarized in tables 79 and 80.

Comparisons of these supply and demand projections indicate that under the conditions assumed in this analysis, fairly substantial increases in prices of timber products relative to the general price level will be necessary to balance demands with available supplies of timber. The potential supply problems and the associated price increases are likely to be greatest for softwood sawtimber.

Softwood Demand-Supply Balances

Projected demands on U.S. forests for softwood sawtimber products—after allowances for imports and exports and improvements in utilization—rise from actual consumption of 46.2 billion board feet in 1970 to a range of 46.5 to 79.7 billion board feet by 2020 under the specified price assumptions (fig. 34). The projection of available supplies of softwood sawtimber from U.S. forests, assuming 1970 management levels and other conditions specified earlier in this section, shows moderate increases to 53.9 billion board feet. The outlook for softwood roundwood is similar—modest increases in supplies and large increases in demand under the lower price assumptions (fig. 35).

It is evident from these comparisons of demands and supplies that a significant rise in prices of softwood stumpage and timber products over 1970 levels will be necessary to balance supply and demand in future decades under the given economic and management conditions.

An equilibrium price path cannot be determined with any exactness, but under the specific conditions assumed, trend level prices of softwood lumber

Table 79. *Summary of softwood timber demand, exports, imports, and demand on and supply from U.S. forests, 1952, 1962, and 1970, with projections to 2020 (medium level) under alternative price assumptions and 1970 level of management.*

Year	Roundwood						Sawtimber[1]					
	Total U.S. demand	Exports	Imports	Demand on U.S. forests	Supply from U.S. forests[2]	Supply-demand balance	Total U.S. demand	Exports	Imports	Demand on U.S. forests	Supply from U.S. forests[2]	Supply-demand balance
	Billion cubic feet	*Billion cubic feet*	*Billion cubic feet*	*Billion cubic feet*	*Billion cubic feet*	*Billion cubic feet*	*Billion board feet*	*Billion board feet*	*Billion board feet*	*Billion board feet*	*Billion board feet*	*Billion board feet*
1952[3]	8.4	0.2	1.3	7.3	7.3	—	39.9	0.6	2.4	38.1	38.1	—
1962[3]	8.5	.4	1.7	7.2	7.2	—	41.7	1.1	4.6	38.2	38.2	—
1970[3]	9.7	1.2	2.1	8.8	8.8	—	47.6	4.6	5.9	46.2	46.2	—
1970 relative prices												
1980	12.3	2.0	2.4	11.9	10.1	–1.8	59.3	6.9	6.6	59.6	48.8	–10.8
1990	13.8	2.1	2.5	13.4	10.7	–2.7	64.0	7.5	6.5	65.0	50.9	–14.1
2000	15.4	2.1	2.6	14.9	11.5	–3.4	68.1	8.1	6.4	69.8	54.2	–15.6
2010	17.2	2.2	2.6	16.8	11.6	–5.2	73.3	8.3	6.3	75.3	54.1	–21.2
2020	18.8	2.2	2.6	18.4	11.6	–6.8	77.7	8.2	6.2	79.7	53.9	–25.8
Rising relative prices[4]												
1980	11.3	2.0	3.2	10.1	10.1	—	52.4	6.9	8.9	50.4	48.8	–1.6
1990	12.1	2.1	3.9	10.3	10.7	.4	52.3	7.4	10.8	48.9	50.9	2.0
2000	12.8	2.2	4.3	10.7	11.5	.8	50.9	8.0	11.4	47.5	54.2	6.7
2010	13.9	2.2	4.4	11.7	11.6	–.1	50.7	8.2	11.6	47.3	54.1	6.8
2020	14.8	2.2	4.6	12.4	11.6	–.8	50.2	8.1	11.8	46.5	53.9	7.4
Relative prices above 1970 averages[5]												
1980	10.7	2.1	3.3	9.4	10.1	.7	49.2	6.8	9.6	46.4	48.8	2.4
1990	12.4	2.2	3.8	10.7	10.7	—	53.8	7.4	10.8	50.4	50.9	.5
2000	13.7	2.2	3.9	12.0	11.5	–.5	57.6	8.1	10.7	55.0	54.2	–.8
2010	15.6	2.2	3.9	13.9	11.6	–2.3	62.4	8.2	10.6	60.0	54.1	–5.9
2020	17.2	2.2	3.9	15.5	11.6	–3.9	66.3	8.2	10.5	64.0	53.9	–10.1

[1] International 1/4-inch log rule.

[2] Projections of supply are defined as the amounts of timber that would be available from harvesting if: (1) Forestry programs continued at 1970 levels, (2) timber removals in the East changed on a straight line basis from actual removals in 1970 to a balance with growth in the year 2000 and thereafter, (3) removals on private lands in the West followed trends suggested by recent management and operating practices, and allowable cuts on public lands remained at the 1970 level.

[3] Data for 1952, 1962, and 1970 are estimates of actual consumption and harvests and differ somewhat from the "trend" estimates shown in tables 75–78.

[4] Relative prices rising from their 1970 trend levels as follows: Lumber—1.5 percent per year; plywood, miscellaneous products and fuelwood—1.0 percent per year; paper and board—0.5 percent per year. This would mean a cumulative increase of 62 percent for lumber by the year 2000, and 17 percent for paper and board.

[5] Relative prices of lumber and plywood 30 percent, miscellaneous products and fuelwood 15 percent, and paper and board 10 percent above their 1970 averages.

Note: Columns may not add to totals because of rounding.

Sources: Data for 1952, 1962, and 1970 based on information published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

Table 80. *Summary of hardwood timber demand, exports, imports, and demand on and supply from U.S. forests, 1952, 1962, and 1970, with projections to 2020 (medium level) under alternative price assumptions and 1970 level of management.*

Year	Roundwood						Sawtimber[1]					
	Total U.S. demand	Exports	Imports	Demand on U.S. forests	Supply from U.S. forests[2]	Supply-demand balance	Total U.S. demand	Exports	Imports	Demand on U.S. forests	Supply from U.S. forests[2]	Supply-demand balance
	Billion cubic feet	*Billion cubic feet*	*Billion cubic feet*	*Billion cubic feet*	*Billion cubic feet*	*Billion cubic feet*	*Billion board feet*	*Billion board feet*	*Billion board feet*	*Billion board feet*	*Billion board feet*	*Billion board feet*
1952[3]	3.5	[4]	0.1	3.5	3.5	—	11.6	0.2	0.3	11.5	11.5	—
1962[3]	3.1	0.1	.2	3.0	3.0	—	11.7	.2	1.0	10.9	10.9	—
1970[3]	3.0	.2	.3	2.9	2.9	—	12.3	.2	1.3	11.2	11.2	—
1970 relative prices												
1980	4.3	.3	.4	4.2	5.2	1.0	16.7	.3	2.0	15.0	15.5	–.5
1990	5.4	.3	.5	5.2	6.3	1.1	20.0	.3	2.0	18.3	18.2	–.1
2000	6.6	.3	.5	6.4	7.4	1.0	23.1	.3	2.0	21.4	20.6	–.8
2010	7.9	.4	.5	7.8	7.4	–.4	27.0	.3	2.0	25.3	20.6	–4.7
2020	9.0	.4	.5	8.9	7.4	–1.5	30.9	.3	2.0	29.2	20.5	–8.7
Rising relative prices[5]												
1980	3.9	.3	.5	3.7	5.2	1.5	14.9	.3	2.0	13.2	15.5	2.3
1990	4.5	.3	.5	4.3	6.3	2.0	16.4	.3	2.4	14.3	18.2	3.9
2000	5.4	.3	.7	5.0	7.4	2.4	18.0	.3	2.7	15.6	20.6	5.0
2010	6.2	.4	.8	5.8	7.4	1.6	19.9	.3	2.8	17.4	20.6	3.2
2020	7.3	.4	.8	6.9	7.4	.5	21.6	.3	2.9	19.0	20.5	1.5
Relative prices above 1970 averages[6]												
1980	3.9	.3	.6	3.6	5.2	1.6	14.3	.3	2.4	12.2	15.5	3.3
1990	4.8	.3	.6	4.5	6.3	1.8	17.1	.3	2.4	15.0	18.2	3.2
2000	5.9	.3	.6	5.6	7.4	1.8	20.0	.3	2.4	17.9	20.6	2.7
2010	7.0	.4	.6	6.8	7.4	.6	23.6	.3	2.4	21.5	20.6	–.9
2020	8.2	.4	.6	8.0	7.4	–.6	27.1	.3	2.4	25.0	20.5	–4.5

[1] International 1/4-inch log rule.

[2] Base projections of supply are defined as the amount of timber that would be available for harvesting if: (1) Forestry programs continued at 1970 levels, (2) timber removals in the East changed on a straight-line basis from actual removals in 1970 to a balance with growth in the year 2000 and thereafter, (3) removals on private lands in the West followed trends suggested by recent management and operating practices, and allowable cuts on public lands remained at the 1970 level.

[3] Data for 1952, 1962, and 1970 are estimates of actual consumption and harvests and differ somewhat from the "trend" estimates shown in tables 75–78.

[4] Less than 50 million cubic feet.

[5] Relative prices rising from their 1970 trend levels as follows: Lumber—1.5 percent per year; plywood, miscellaneous products and fuelwood—1.0 percent per year; paper and board—0.5 percent per year.

[6] Relative prices of lumber and plywood 30 percent, miscellaneous products and fuelwood 15 percent, and paper and board 10 percent above their 1970 averages.

Note: Columns may not add to totals because of rounding.

Sources: Data for 1952, 1962, and 1970 based on information published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

Softwood sawtimber - demand on U.S. forests and domestic supply

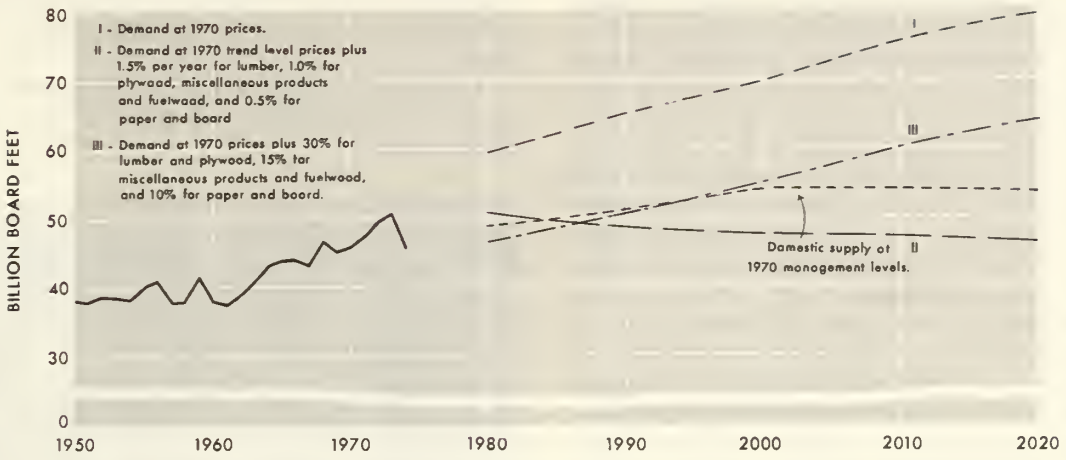

Figure 34

Softwood roundwood - demand on U.S. forests and domestic supply

Figure 35

(relative to the general price level) might average 30–40 percent above 1970 by 2000, with a further increase of roughly 70–80 percent by the year 2020. Increases of these magnitudes would be generally consistent with past trends when supplies and demands for softwood lumber were balanced at successively higher relative prices.

Equilibrium price increases for the major timber products could also be expected to differ as in the past. For example, in contrast to the 30–40 percent increase for softwood lumber and plywood, relative prices of paper and board might be no more than 10–15 percent above 1970 prices by 2000. Greater increases in prices may be necessary in the pulp and paper industry, however, to attract the capital required to meet projected demands.

Stumpage price increases also could be expected to be considerably greater on a percentage basis than increases in equilibrium prices of processed products. For example, in the past, increases of

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50–60 percent in softwood lumber prices have resulted in a rise of over 100 percent in relative average prices of softwood sawtimber stumpage.

In view of the many uncertainties involved in projecting both demand and supply, estimates of prices at which they might be balanced must be regarded as very general approximations that would only be realized under the assumed conditions underlying these specific projections.

Many factors could, of course, lead to price paths different from those indicated by this analysis. These include different rates of economic growth, different trends in technology, or demand elasticities different from those assumed, all of which would indicate change in projected demand.

Supplies could be lower than projected as a result of various factors such as greater diversion of forest lands to other uses than was assumed; or more constraints on timber management because of environmental factors, nontimber objectives of forest owners, or extraordinary mortality losses. Supply responses to price changes also could result in higher or lower supply trends than shown by these projections.

Hardwood Demand-Supply Balances

Demands on U.S. forests for hardwood timber rise from about 2.9 billion cubic feet in 1970 to a range of 5.0 to 6.4 billion cubic feet in 2000 and 6.9 to 8.9 by 2020 under the alternative price assumptions and the medium level of population and economic growth used in this analysis (table 80).

Projected supplies increase from 2.9 billion cubic feet in 1970 to about 7.4 billion cubic feet by 2000 and remain constant through 2020. Thus, total supplies of hardwood potentially available in terms of cubic feet exceed projected demands through 2000, but fall increasingly short thereafter. While this implies that increases in relative prices are not likely in the next three decades, wide differences in timber quality and availability described below indicate a variable outlook for supply-price relationships.

In the case of hardwood sawtimber, projected demands on U.S. forests—after allowances for imports and exports—rise from 11.2 billion board feet in 1970 to a range of 19.0 to 29.2 billion board feet in 2020, depending on the price assumption specified (table 80). Projected supplies rise from 11.2 billion board feet in 1970 to 20.5 billion board feet by 2000 and stabilize at about that level.

In general, the projections for hardwood timber show a more favorable supply and price outlook than for softwoods. However, it is quite possible, as in the case of softwoods, that not all of the potentially available supplies indicated by the base projection will, in fact, be available, particularly at 1970 price levels. Recent increases in relative prices of hardwood stumpage and especially for certain preferred species and higher grades of timber indicate that statistics on total inventories and net growth overstate volumes economically accessible and available for sale by the large numbers of private owners who own most of the hardwood timber resource.

Hardwood timber inventories and growth are also far from homogeneous, and statistics on supply and consumption do not include the same mix of species and sizes of timber. Much of the growth and available supply of hardwoods is in small trees and species for which markets are limited. A major part of the harvest, on the other hand, is concentrated on larger sizes of preferred species such as white oak, sweetgum, yellow birch, hard maple, walnut, and black cherry. Removals of such higher grade material and species have been close to or above annual growth.

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Hardwood forests can support larger harvests. However, removals of higher quality timber of preferred species, such as the yellow-poplar shown in this picture, are close to or greater than growth.

It seems likely, therefore, that relative prices of hardwood timber products may also rise in about the same way as those of softwoods, particularly for the preferred species and larger sizes.

Implications of Rising Relative Prices for Timber Industries

The prospective increases in relative prices of stumpage and timber products can be expected to have significant impacts on softwood lumber and plywood industries. Limitations on timber supplies and increases in prices will constrain expansion potentials in housing and other markets, and necessitate greater dependence on competitive materials for many uses.

Producers of high-quality hardwood lumber and hardwood plywood face a similar situation of limited and higher cost wood supplies. The outlook is better, however, for producers of hardwood construction timber, pallet lumber, railroad ties, and other products that can be manufactured from the lower quality hardwoods that are in relatively abundant supply.

The outlook for the pulp and paper industry is more favorable to the extent that this industry can use small and low-quality material, hardwoods, plant and logging residues, and recycled fibers as well as round softwood pulpwood. Nevertheless, price increases for timber used by the lumber and plywood industries can be expected to have direct impacts on pulpwood prices. All forest industries compete to some extent for the same sizes and species of timber, and price rises for larger and higher quality trees can be expected to extend to some degree to the entire timber resource. The pulp and paper industry (as well as other timber users) thus has a major interest in intensifying forest management and improving utilization to meet potential timber demands.

Higher prices for timber and timber products will, of course, improve the profitability of forest management and thus could encourage more investments in timber growing and expansion of public and private forestry programs. This would help increase timber supplies although the supply response is likely to be limited.

Prospective trends in timber availability also point to changes in the geographic location of timber industries. A continuing drop in softwood timber supplies in the West can be expected, while a substantial expansion of timber supplies and wood-based industries is anticipated in the South.

Economic and Environmental Effects of Rising Relative Prices

If timber supplies are insufficient to meet growing demands for lumber, plywood, and other wood products, builders and other users of these materials can and will shift many demands to competing materials such as metals, plastics, and concrete. Considerable substitution of this nature, has, of course, occurred in the past with increasing relative prices of lumber. Mineral-based products and steel have made heavy inroads in many traditional wood uses in construction, for example, while plastics have been increasingly used for such items as boats, furniture, and packaging.

Higher prices of timber products and a shift to greater use of competitive materials will lead, however, to increased costs of houses, furniture, and many other goods. Although total and per capita incomes are assumed to increase substantially, higher materials costs would necessarily have some adverse impacts on volumes and quality of housing production, for example, and thus on consumer welfare.

Continuing shifts to other raw materials necessitated by limited timber supplies could also increase adverse industrial impacts on the environment. The air, water, and land pollution resulting from production of substitute materials such as steel, concrete products, and aluminum is of greater magnitude than in the case of timber products such as lumber and plywood. In many cases, such impacts apparently can be reduced to acceptable levels, but the expenditures necessary to control pollution would tend to increase costs of these materials.

Energy requirements and costs of processing competing materials also are much higher than for timber products. It is estimated that use of steel framing for exterior walls in residential construction, for example, requires over three times the amount of processing energy needed to produce lumber for comparable installations. For aluminum and concrete blocks, energy requirements are estimated to average more than eight times the requirements for lumber. There are likewise substantial differences in typical heating and cooling costs with alternative materials that favor use of wood products in housing construction.

While such estimates cannot be viewed as exact measures of energy requirements because of variations in structures, building practices, and other factors, differences in use of energy as well as relative pollution impacts are believed to be of considerable significance in evaluating the future situation and in developing programs to assure future raw material supplies.

Among other aspects of the question of substitution is the increasingly serious problem of waste disposal. Wood products that are not recycled for paper and board, for example, are highly biodegradable in contrast to most competitive materials.

Another important consideration in a shift to greater use of nontimber materials is the longrun effect of accelerated use of nonrenewable stocks of ores and energy materials. Coal, petroleum, and natural gas once used are gone forever, and minerals

can be extracted only at rising real costs. Forests, on the other hand, constitute a renewable resource that can continue to produce timber indefinitely.

Substantial portions of the aluminum and steel consumed in the United States, moreover, are derived from foreign sources, and projections indicate the necessity of more and more U.S. dependence on foreign supplies of metals, petroleum, and other materials. Consequently, increased use of wood substitutes could have adverse impacts on the U.S. balance of payments.

For these various reasons, programs to produce increased crops of timber, such as those described below, may have much more justification than would be indicated by conventional investment analyses.

Opportunities for Increasing Timber Supplies

The outlook described above, of rising relative prices of timber and timber products, and the associated economic, social, and environmental consequences can be changed. Under intensive management, the Nation's commercial timberlands could produce much larger quantities of timber than shown by the base supply projections.

Opportunities for Management Intensification

Increased timber production can be achieved by a variety of measures, including accelerated regeneration, stand conversion, stand improvement, commercial thinning, fertilization, water control, improved harvesting practices, and intensified protection.

Regeneration.—Much has been done to improve regeneration following logging, both by modifying harvesting practices to obtain natural regeneration and by establishment of planted stands through site preparation and planting or seeding.

Large additional gains in timber supplies can be achieved by expansion of planting efforts, by greater use of genetically improved planting stock, and proper stocking control. Considerable progress has been made already in use of improved stock, particularly in the South. Programs underway will steadily expand the use of such stock in the years ahead. Reduction of the regeneration period after logging also is important, particularly in a number of western forest types and on pine types in the South where hardwood encroachment after harvesting is a problem.

Accelerated planting efforts, as in the case of much current planting, will often require such measures as clearing areas of economic size; piling, chipping, disking, or burning logging debris; bedding prior to planting to improve drainage; chemical destruction of competing vegetation; or combinations of such measures.

Stand conversion.—Many areas, in both the East and the West Coast, support poorly stocked stands of inferior species or quality that will produce little volume or value growth. Clearing of such stands and replanting is being done successfully on a rather wide scale on industrial and certain other lands. Numerous opportunities exist for expansion of similar stand conversion programs, especially in the South. Also, in the case of some stagnated stands of species such as lodgepole pine in the West, removal of the present trees and replacement by new stands of the same or different species is the only way to achieve full use of the site potential. Such conversion in some areas, however, may be limited by low sites or because of wildlife or other nontimber considerations.

Stand improvement.—In most timber types, individual trees assert dominance over the others and stands develop efficiently. In other cases, crowding becomes progressively more serious and long rotations are required to produce merchantable wood. At its worst, this crowding results in stagnation, especially on poor sites, with resulting spindly stands of small trees that never become merchantable—at least by prospective standards.

Precommercial thinning early in the life of overcrowded stands would have major impacts on timber

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Poorly stocked stands of inferior species are common in the eastern hardwood forests. Volume and value growth can be greatly increased by stand conversion or stand improvement measures such as cull tree removal.

yields. Such thinning produces no immediate usable wood, but has its payoff in faster growth, shorter rotations, more growth in useable trees, and higher quality wood.

Precommercial thinning of heavily stocked stands is thus one of the major technical opportunities for increasing yields in many forests. Other measures that require out-of-pocket investments to increase timber volumes and values include removal of undesirable overstory trees in young stands having sufficient "crop" trees to utilize the site.

Commercial thinning.—Cutting of merchantable trees to improve spacing and stimulate growth of crop trees is still a relatively limited practice in the United States. Nevertheless, numerous research studies indicate that commercial thinning often can provide early returns, utilize material otherwise lost as mortality, and concentrate growth on the more valuable trees. This is particularly the case on lands where production of sawtimber is the objective of management.

Fertilization.—There has been increasing experience in recent years in the use of forest fertilizers to accelerate and improve tree growth. Most of the activity in this regard has been in the Pacific Northwest and in the South—practically all by industrial owners.

Experience suggests that timber yields can be increased rather substantially with applications of nitrogen and, in some cases, with other nutrients such as phosphorus. However, with the increase in fertilizer costs resulting from the rise in energy prices, it may not be economically feasible to fertilize large acreages, even with higher timber prices.

Protection against insects and diseases.—Insects and diseases take a heavy toll of timber by killing trees and by reducing timber growth. For example, the annual mortality and growth reduction attributable to only three pests—western dwarf mistletoes, western bark beetles, and southern pine beetles—are estimated to equal about 13 percent of the current timber harvest.

A number of major protection programs against forest pests has been undertaken in past years. For the most part, these have been only partially successful, presumably because not enough has been known about how to deal with these pests.

Protection against fire.—The largest and most effective forestry effort in the United States, has been in the control of forest fires. The results have been remarkable, with a decline in area burned from 30 to 40 million acres annually at the beginning of the century to about 5 million acres annually, in the late 1960's.

There still appear to be important opportunities, however, to further reduce fire losses and costs through development and use of improved technology in fire prevention, presuppression, and suppression. These include better understanding of ways to reduce numbers of fires, development of improved fire detection systems, and development of techniques for more effective control of fires. Through such means, fire suppression, particularly of large fires that characteristically result in most fire damage, could be more efficient and losses correspondingly reduced.

Fire losses also might be cut by reducing fuel accumulation on cutover areas through development of markets for logging residues and/or improved cleanup of cutover areas. Further improvement of techniques for use of prescribed fire in hazard reduction could also help reduce the intensity of and losses to wildfires.

Salvage.—Harvesting of a larger portion of the 2.8 billion cubic feet of softwood timber killed annually by fire, insects, or other causes also represents an important potential for increasing log supplies in some areas.

Economic Opportunities for Timber Management Intensification

There are opportunities for substantial investments at fairly good rates in timber management practices. A recent Forest Service analysis of a limited range of opportunities on nonindustrial private and National Forest lands indicated that $55 million per year could be invested in the opportunities which would yield more than 5 percent per year. With this investment an estimated 1.2 million acres per year of nonindustrial private lands could be treated with a yield increase of 3.7 billion board feet per year in the fourth decade after the start of the program. On National Forest lands, an additional 0.3 million acres could be treated annually with a yield increase of 3.4 billion board feet per year in the fourth decade. These yield increases are 19 percent and 23 percent of the projected softwood board feet supply in 2020 for nonindustrial private and National Forest owners, respectively.

A pilot study of management opportunities in oak-hickory stands indicated that 23 percent of the oak-hickory area in the Northeast, some 8.8 million acres, were capable of returning 5 percent on investments with product prices 30 percent above the 1970 level. Harvests would increase an estimated 17 percent over 6 decades but, because growth is shifted to higher quality trees, the value of removals would be 40 percent above that available under current management.

A pilot study of maple-beech-birch investment op-

portunities in the North Central region indicated that 11 percent of the area or 1.3 million acres could be profitably treated with product prices 30 percent above the 1970 level. In the sixth decade following treatment, timber yields would be increased by 0.5 billion board feet annually.

The Importance of Forest Ownership

While there are many technical and economic opportunities for increasing timber growth and harvests in the various regions of the United States, a number of ownership constraints tend to limit practical increases in timber supply. The long investment period for most forestry practices is a significant barrier to intensified management by most private owners. Limitations on capital and lack of knowledge of the available opportunities also inhibit management. In addition, land use objectives not compatible with timber production and other factors have a marked influence on the actions of forest owners.

Ownership constraints are most important on the 59 percent of the Nation's commercial timberland owned by several million nonindustrial private owners—farmers, businessmen, housewives, power companies, mining companies, and numerous other occupational groups and types of businesses. A number of studies have shown that these owners have many objectives in owning forest lands, widely differing characteristics and attitudes, and varying willingness and capacity to invest funds in timber growing. The population of owners also is constantly changing in terms of individuals, types of owners, and size of holdings.

In view of the characteristics of these nonindustrial private owners, it seems clear that substantive increases in timber supplies from this source can only be achieved by such measures as extensive public cost-sharing of management practices, the provision of technical assistance by public agencies and timber industries, leasing and management of timberlands by the timber industries, pooling arrangements for the management of small holdings, and legislative controls on management and timber cutting practices.

Environmental Impacts of Intensified Management

Environmental considerations are having increasing effects on the cost of forest management and timber processing. They also affect the acceptance of timber-growing and harvesting practices by the public.

Intensification of forest management by such measures as thinning, timber stand improvement, reforestation, prescribed burning, fertilization, etc.; and associated timber cutting, road construction, slash burning, or other disturbances; has varying impacts on forest resources and uses. It is difficult to generalize about the net impacts of intensified forestry practices on nontimber values. Conditions often vary widely, knowledge of specific impacts is generally lacking, and plus and minus factors may be offsetting.

Water yields, for example, will probably increase somewhat if a substantial portion of the timber in a drainage is removed. Excessive stream sedimentation, with a reduction in water quality, also can occur if roads, landings, and logging practices are not carefully planned and controlled. Forest fertilization will require careful application to minimize nutrient input to streams and lakes.

Habitat for some kinds of wildlife is generally improved with thinnings and other measures which open the forest canopy and increase supplies of food plants. Conversion of brush fields or poor-quality stands by site preparation and planting, on the other hand, may damage habitat for other species, particularly in plantations where complete forest canopies develop.

Recreational access for hunting and fishing and some other recreation travel is usually improved with road construction for logging and other forestry operations. Adverse recreational impacts are also common, however, as in cases where esthetic qualities of forest areas for recreational viewing, hiking, or camping are reduced by logging operations. Consequently, management of "visual resources," particularly in mountainous areas in public ownership, may limit the extent to which timber management can be acceptably intensified.

Costs of land management must include careful design and location of roads and cutting areas if erosion or other environmental impacts are to be minimized. Fire control problems and costs are also likely to be increased with greater access to the forest and increases in production of slash or debris from expanded harvesting operations. Conventional slash burning and prescribed burning may be constrained by opposition to resulting air pollution effects or other impacts.

Environmental impacts from accelerated reforestation, stand improvement, or other forestry operations are likely to be limited at any given time to a small percentage of the total forest area.

In West Coast stands under intensive management, it was estimated that entries into a forest will normally be made with some type of equipment every 10 years or so for such purposes as planting, precommercial thinning, prelogging, and final harvest. It may also be necessary to enter the forests on

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A heavily cut upland hardwood area. Generally, such areas revegetate rapidly although another commercial timber harvest is decades away.

other occasions for fire control or salvage of blowdown or insect-killed timber.

The type of soils and terrain and the type of equipment used are major considerations in determining the amount and consequences of such activities. In some areas of difficult terrain, for example, road construction may be unacceptable in view of the need to protect scenic resources, prevent soil movement, or protect water values. Under such conditions, timber harvesting may be feasible only with systems involving skylines, balloons, or helicopters.

In the future, various modifications of forestry practices may be essential, particularly on public lands, to insure that intensification of timber management does not seriously impair the environment or damage nontimber uses. These may include treatment of relatively small areas, for example, and cleanup of thinning and logging slash. Protection of stream channels for wildlife and water values will require that cutting be restricted along streams. Leaving uncut areas for animal escape and cover may be necessary to maintain desired animal populations. Programs for salvage of dead and dying trees may have to be avoided in some areas, and patches of other timber left to protect food supplies and nesting sites for certain animals and birds. Such practices may have appreciable effects on allowable cuts, particularly on public lands.

Extending Timber Supplies Through Improved Utilization

In addition to the opportunities for increasing timber supplies through management intensification, there are opportunities for extending timber supplies through improvement in timber utilization.

Much progress has been made toward more complete utilization of timber on logging operations and in the processing of timber products. Nevertheless, in 1970, nearly 1 billion cubic feet of plant residues was burned or discarded. On logging operations, an additional 1.6 billion cubic feet of logging residues from growing stock, plus sizeable volumes of limbs and other material from cull and dead trees, was left in the woods unutilized. Residual rough and rotten trees passed by in logging also represented a major potential source of fiber. Unsalvaged mortality of widely scattered trees lost to fire and other destructive agents totaled an estimated additional 4.2 billion cubic feet. Much of this material is potentially usable.

Development of methods of log extraction that will permit less road construction and minimize adverse environmental impacts could make timber management feasible on areas where timber harvesting is now uneconomic or unacceptable. Major advances are considered possible in use of aerial sys-

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There are still large volumes of residues left after logging—much of this material is potentially usable.

tems of logging, including use of cables, balloons, and helicopters, and in development of roads suitable for thinning operations.

Accelerated development and adoption of new processing technology in lumber and plywood manufacture could have the effect of extending available timber supplies. Much additional progress appears possible, for example, in adoption of thin kerf saws to increase lumber yields, and in reducing or eliminating errors of judgment in cutting logs for maximum yield and optimum grade recovery. Lumber might also be sawed with greater precision and smoother surfaces and used "rough sawn" as is the custom in some foreign countries. Improved equipment for more accurate grading of structural lumber also could make possible greater efficiency in use of wood in construction.

Substitution of hardwoods for softwoods in construction, pulp manufacture, and possibly other uses would also help extend available softwood timber supplies.

Further development of particleboards and particleboard-core products from residues or underutilized roundwood to serve in lieu of softwood lumber and plywood in various uses is possible. For example, particleboard is now being produced in limited quantities for construction uses, and current research indicates that various types of board could be made from a wide variety of materials of both softwood and hardwood species for such uses.

In the pulp and paper industry, continued development of higher yielding pulping processes could lead to reduced wood use and a broadening of the resource base for pulping. Greater use of wastepaper and board beyond that assumed in the demand projections may be possible through improved technology and/or changes in economic conditions or programs to increase consumer acceptance of paper with significant proportions of recycled fibers. Development and adoption of more efficient methods of whole-tree harvesting and bark-chip separation also could greatly expand the raw material base for pulpwood, and thus improve the supply situation for other timber products.

Improved construction designs for housing and other structures, and the development and adoption of improved construction methods, could aid in conserving wood materials and reducing costs of end products. These might include stress skin panel construction systems, for example, or other improvements in design of structures or components. Many wooden structures are overdesigned and use more

wood than necessary because of tradition, building codes, inadequate grading, or lack of knowledge. It is estimated that use of more efficient construction methods in residential building, for example, could reduce wood use as much as 10 to 20 percent with no significant sacrifice in performance. Also, increased use of wood preservative treatments in some construction uses would extend wood supplies.

The Role of Research

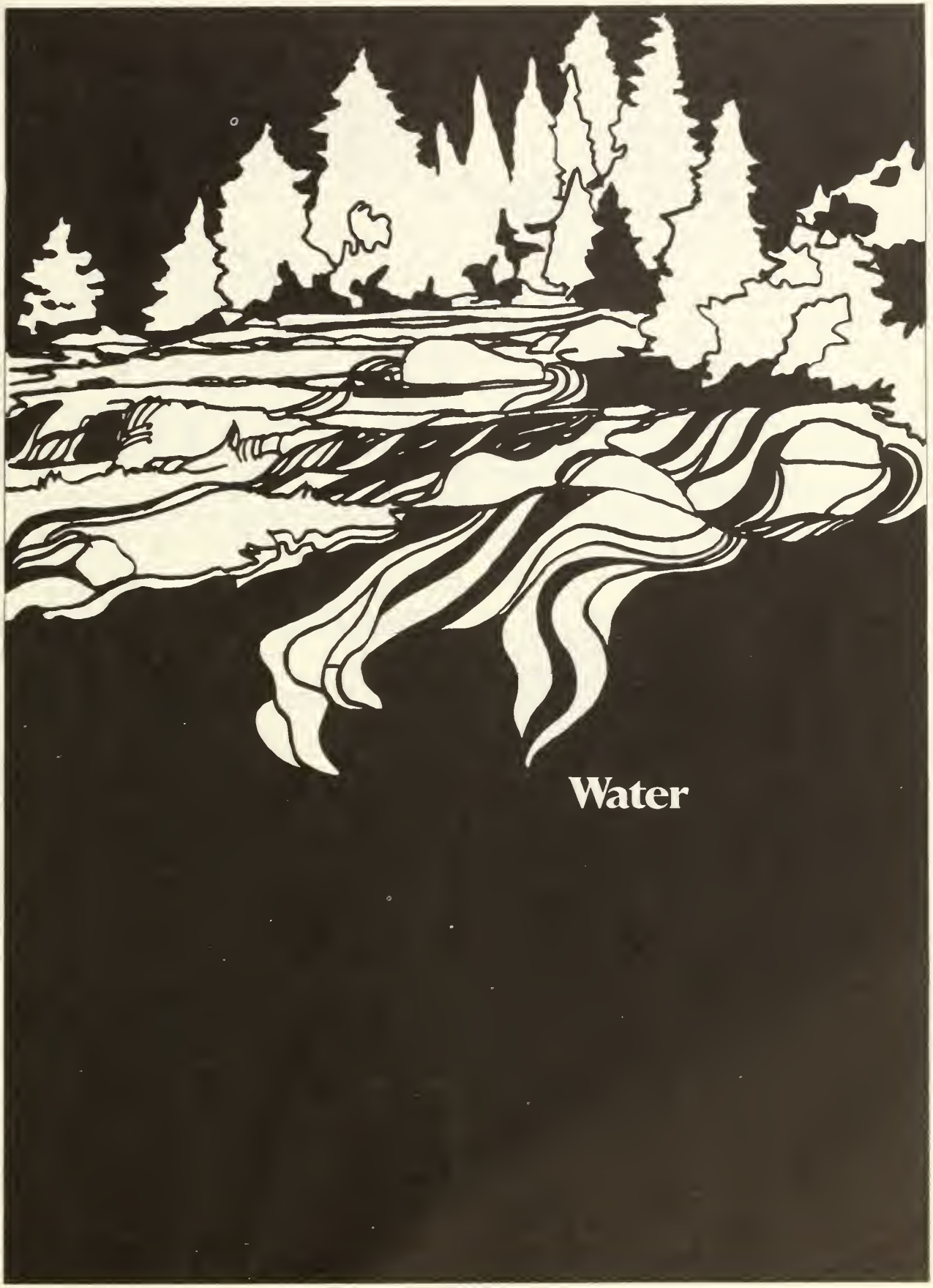
Much can be done to improve utilization and increase timber growth and harvests by better use of existing technology. But investments in intensified management and utilization could be made more effective by expanding the technological base for such efforts. More information is needed, for example, about the responses of forest stands of different types, ages, and sites to treatments such as thinning. Before the most effective tree fertilizing programs can be achieved, more knowledge must be obtained on the response of trees on various soils, and effects of fertilizers on the environment. Research on genetic improvements in timber growing should include improved methods of progeny testing to detect natural resistance to insects and diseases.

There are substantial areas of poorly stocked forests, and areas where planting costs are high, where lower cost techniques for site preparation and planting would improve returns from forest investments. Better knowledge of spacing control in precommercial thinning and subsequent intermediate cutting could help increase output of both timber and nontimber values.

In many forest types, development of more effective methods of timber harvesting that will bring about natural regeneration of desirable timber species is of key significance in assuring prompt and low-cost establishment of new stands and the protection of esthetic or other nontimber values. Improvement of aerial logging techniques using skyline systems, for example, could increase timber harvests as well as enhance environmental values.

It is not possible to qualify the impacts of accelerated research efforts, nor rates of subsequent extension and application of new technologies. However, it is believed there are substantial potentials for increasing timber growth and for extending timber supplies beyond projections in this chapter by development and application of improved technology.

In addition, through research, it may be possible to develop ways of integrating and balancing multiple uses of forest land and reducing the conflicts which are likely to result from the rapidly expanding demands for timber, grazing, recreation, water, and other forest related goods and services.


Water


WATER RESOURCE REGIONS
NEW ENGLAND, 101-106
MIDDLE ATLANTIC, 201-206
SOUTH ATLANTIC-GULF, 301-309
GREAT LAKES, 401-408
OHIO, 501-507
TENNESSEE, 601-602
UPPER MISSISSIPPI, 701-705
LOWER MISSISSIPPI, 801-803
SOURIS-RED-RAINY, 901
MISSOURI, 1001-1011
ARKANSAS-WHITE-RED, 1101-1107
TEXAS-GULF, 1201-1205
RIO GRANDE, 1301-1305
UPPER COLORADO, 1401-1403
LOWER COLORADO, 1501-1503
GREAT BASIN, 1601-1604
COLUMBIA-NORTH PACIFIC, 1701-1707
CALIFORNIA-SOUTH PACIFIC, 1801-1807
ALASKA, 1901
HAWAII, 2001-2004
CARIBBEAN, 2101-2102
LEGEND
REGIONS
AGGREGATE SUBAREAS
FEBRUARY 22, 1974

Figure 36

This chapter presents information on (1) recent trends in the withdrawal of water for consumptive and nonconsumptive uses with projections of demand to 2020, (2) the prospective water supply situation, (3) comparisons of projected water demands with supplies and identification of the location and significance of potential quantity imbalances, (4) identification of major water quality problems, and (5) opportunities for increasing water supplies and improving water quality.

Much of the information in this section has been condensed from preliminary information prepared for the ongoing study of the Water Resources Council "The 1975 Assessment of Water and Related Land Resources."[1] Where data are not yet available from the 1975 study, information is taken from the preceding Water Resources Council study, "The Nation's Water Resources."[2] Much of the material on water quality was condensed from a report prepared by the Environmental Protection Agency, "National Water Quality Inventory Report for 1974."[3]

There have been a number of other recent studies which contain information on the Nation's water resources and which supplement the above work. These include:

National Water Commission. Water policies for the future, final report to the President and to Congress. U.S. Government Printing Office, Washington, D.C. 579 p. 1973.

Wollman, Nathan, and Gilbert Bonem. The outlook for water. Resources for the Future, the Johns Hopkins Press. 286 p. 1971.

U.S. Water Resources Council. Water regions and subregions for the national assessment of water and related land resources. Water Resources Council, Washington, D.C. 75 p. 1970.

Sopper, William. Effects of timber harvesting and related timber management practices on water quality in forested watersheds. Journal of Environmental Quality, Vol. 4, No. 1: 24–29. 1974.

Kunkle, Samuel H. Water, its quality often depends on the forester. Unasylva, Vol. 26, No. 105: 10–16. 1974.

In general, water is not a highly transportable commodity. Transporting water outside natural watersheds is usually very expensive—often prohibitively so for all but the highest value uses. As a result, an analysis of demand-supply imbalances at the national level would be of limited use since it is usually impractical to transport the surpluses of one area to offset the shortages in other areas. Thus, nearly all water problems are local or regional. In recognition of this fact, the projections of water demands and supplies are presented by Regions that are representative of geographic areas with common or unique water management situations.

The geographic delineations used in this study are shown in figure 36. The "Regions" described on the map margin as New England (01), Middle Atlantic (02) . . . , Caribbean (21) are delineated by solid lines. The second order delineations are subdivisions of the first, and are described as "aggregated subareas." These aggregated subareas, delineated by the dotted lines in figure 36, include a group of counties with boundaries that closely approximate the area drained by either (1) a river system or systems, (2) a reach of a river and its tributaries, (3) a closed basin or basins, or (4) a group of rivers forming a coastal drainage area.

The study will present general demand-supply information by Regions to provide the reader with an overview of the water situation. The portion of the study dealing with problem identification will further delineate the water supply and consumptive use

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Transporting water outside natural watersheds by pumping or syphoning is often prohibitively expensive for all but the highest value uses.

[1] U.S. Water Resources Council. "The 1975 assessment of water and related land resources." (In process.)

[2] U.S. Water Resources Council. The Nation's water resources. The first national assessment of the Water Resources Council, U.S. Government Printing Office, Washington, D.C. 1968.

[3] United States Environmental Protection Agency. National water quality inventory, Vol. I and II. U.S. Government Printing Office, Washington, D.C. 1974.

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demands into the aggregated subareas to facilitate the identification of water problems to smaller more meaningful areas.

The Demand for Water

Water use falls into three major categories: (1) withdrawal uses that remove water from its natural course; use it, and then return it to the stream or ground source where it is available for reuse; (2) consumptive uses which represent the portion of withdrawal that is consumed through evaporation or transpiration or by discharge to irretrievable locations such as the ocean; and (3) instream uses such as boating, fishing, navigation, and hydroelectric power.

The ongoing study of the Water Resources Council[4] contains estimates of water withdrawals and consumptive use in 1975 and projections of demand for 1985 and 2000. The projections in this report for 2010 and 2020 have been made by the Forest Service by extending the general trends established by the above projections. Those for 1980 and 1990 were also made by the Forest Service by interpolating the Water Resources Council projections.

Water Withdrawals by Major Use

Water is withdrawn for many purposes; domestic use from both central and noncentral supply systems, manufacturing, mineral production, cooling in steam electric generation plants, irrigation, livestock consumption, and the administration of public lands.

Water withdrawal for all uses in 1975 was estimated at 359 billion gallons per day (table 81). Agricultural irrigation was by far the largest use accounting for more than 50 percent of the total. Withdrawal for steam electric cooling was second with 93 billion gallons per day or 26 percent. Another 14 percent was used in manufacturing. Nearly all of the remainder was withdrawn for domestic use and minerals production.

The withdrawal demand for water is projected to drop to 284 billion gallons per day in 2020 (medium level). Most of the projected decrease occurs before 2000 and is concentrated in manufacturing, steam electric cooling, and irrigation.

Manufacturing withdrawals show the greatest decline in the 1975–2000 period falling from 51.0 billion gallons per day to 19.5 billion gallons. This reduction mostly reflects expected increased use of recycling facilities to avoid pollution and meet environmental standards.

Although electric power capacity is expected to increase substantially in the future years, water withdrawals for cooling declines from 92.6 billion gallons per day in 1975 to 70.0 in 2000. The projected drop reflects anticipated increases in the use of dry cooling towers to avoid thermal pollution.

Domestic uses of water are projected to increase from 22.2 billion gallons per day to 30.2 billion gallons per day by 2000 largely because of population growth and increases in per capita use. Most of this growth will be met through centrally supplied systems with noncentral systems remaining about constant.

Other uses show moderate increases but projected withdrawals are relatively small. However, many of these uses are concentrated in small areas of limited supply and could be quite important regionally. This is especially likely if large scale coal and oil shale development takes place in the West.

[4] The 1975 assessment of water and related land resources, op. cit.

Table 81. *Water withdrawals in the United States in 1975 by major use, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Major use	1975	1980	1990	2000	2010	2020
Domestic use	22,196.7	23,881.8	27,073.6	30,172.2	32,454.4	34,773.1
Manufacturing	51,011.8	33,708.9	22,363.1	19,477.7	15,477.3	13,590.7
Minerals	7,536.9	8,086.9	9,517.3	10,910.9	12,108.9	13,409.2
Crop irrigation	181,379.0	183,120.4	176,713.3	167,320.9	163,417.3	156,360.6
Livestock	1,844.2	1,986.6	2,223.0	2,443.4	2,648.1	2,836.9
Steam electric	92,587.3	89,161.6	79,811.3	70,040.3	61,873.8	59,477.5
Fish hatcheries	628.0	663.8	707.7	726.0	763.0	800.0
Public lands	1,593.5	1,677.7	1,894.8	2,114.7	2,269.9	2,448.1
Total	358,777.4	342,287.7	320,304.1	303,206.1	291,012.7	283,687.1

Note: Data are preliminary and subject to revision.

Source: U.S. Water Resources Council. *The 1975 assessment of water and related land resources.* (In process).

As indicated in the tabulation below, the low and high assumptions on growth in population, economic activity and income presented in the basic assumptions chapter of this study have important impacts on demands for water.

Year	Assumptions	Withdrawal use (billion gallons a day)
1980	Low	325.0
	Medium	342.3
	High	360.0
1990	Low	295.0
	Medium	320.3
	High	355.0
2000	Low	265.0
	Medium	303.2
	High	350.0
2010	Low	235.0
	Medium	291.0
	High	345.0
2020	Low	200.0
	Medium	283.7
	High	340.0

The range in the 1980 projections is small, only 35 billion gallons per day. The range in the more distant future is much greater, for example, 140 billion gallons per day in 2020. It is apparent that demands are quite sensitive to population and economic growth changes.[5] Demand for most uses is also quite sensitive to income changes primarily because of the impacts of increased mineral development, manufacturing, and electric cooling facilities.

Water Withdrawals by Region

There is a wide variation among the Water Resource Regions in the volume of water withdrawals (table 82, fig. 37). The largest withdrawals are in the Columbia-North Pacific and the California-South Pacific Regions where they totaled about 88 billion gallons per day in 1975—more than one-fifth of all U.S. water withdrawals. Withdrawal in the Missouri Region in 1975 was about 39 billion gallons per day. In the East, withdrawals in the Great Lakes and Ohio Regions amounted to nearly 75 billion gallons per day in 1975. Together, the above Regions, along with the South Atlantic Gulf and Middle Atlantic Regions, accounted for 68 percent of the U.S. withdrawals.

Water withdrawals are projected to decline in most Regions. The biggest decline is anticipated in the Middle Atlantic, Great Lakes, and Ohio Regions where manufacturing activities are concentrated.

[5] Ranges were not developed for the major water uses or for Water Resource Regions because it was not feasible to obtain the necessary inputs of other agencies which have the responsibility for preparing estimates of this kind.

Table 82. *Water withdrawals in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	4,797.1	4,234.6	3,150.0	2,490.5	2,357.3	2,386.4
Middle Atlantic	16,161.6	14,684.3	13,179.7	11,973.2	9,826.9	10,572.3
South Atlantic-Gulf	27,021.9	25,453.6	24,827.8	24,940.8	22,291.5	20,616.1
Great Lakes	39,378.5	32,700.4	27,915.2	24,693.2	23,119.4	20,518.7
Ohio	35,283.4	28,722.4	20,615.8	14,832.1	9,822.7	8,297.9
Tennessee	9,130.0	7,767.2	5,816.3	4,767.8	3,254.3	2,118.1
Upper Mississippi	12,707.4	11,222.9	8,744.4	6,840.6	4,793.2	4,280.9
Lower Mississippi	15,097.7	15,578.6	19,149.8	23,482.1	27,547.2	31,691.1
Souris-Red-Rainy	360.4	336.6	350.5	446.0	546.6	656.4
Missouri	38,886.9	43,351.4	45,580.1	45,796.0	50,385.4	52,823.0
Arkansas-White-Red	12,730.2	12,926.7	12,921.8	12,780.9	12,876.6	12,841.3
Texas-Gulf	16,757.5	16,133.9	14,959.1	13,926.6	12,296.6	10,633.2
Rio Grande	9,509.6	9,551.7	9,621.5	9,790.5	10,058.5	10,292.8
Upper Colorado	8,456.5	9,083.5	9,195.0	9,378.0	9,957.9	10,230.8
Lower Colorado	9,460.1	9,137.8	8,770.5	8,456.5	7,793.1	7,241.0
Great Basin	12,883.9	11,640.9	10,474.8	9,738.5	8,056.2	6,819.2
Columbia-North Pacific	45,758.1	47,433.0	45,886.1	42,601.8	42,958.2	41,489.2
California-So. Pacific	41,737.3	39,826.8	36,957.8	34,409.8	31,237.5	28,380.3
Alaska	290.6	308.7	362.0	424.7	443.8	462.8
Hawaii	1,585.3	1,438.9	1,205.0	1,023.0	983.5	946.5
Caribbean	783.4	753.8	620.9	414.5	406.3	398.1
Total	358,774.4	342,287.7	320,304.1	303,207.1	291,012.7	283,696.1

Note: Data are preliminary and subject to revision.

Source: U.S. Water Resources Council. *The 1975 assessment of water and related land resources*, op. cit.

Estimated water withdrawal and consumptive use by water resource region, 1975 and 2000

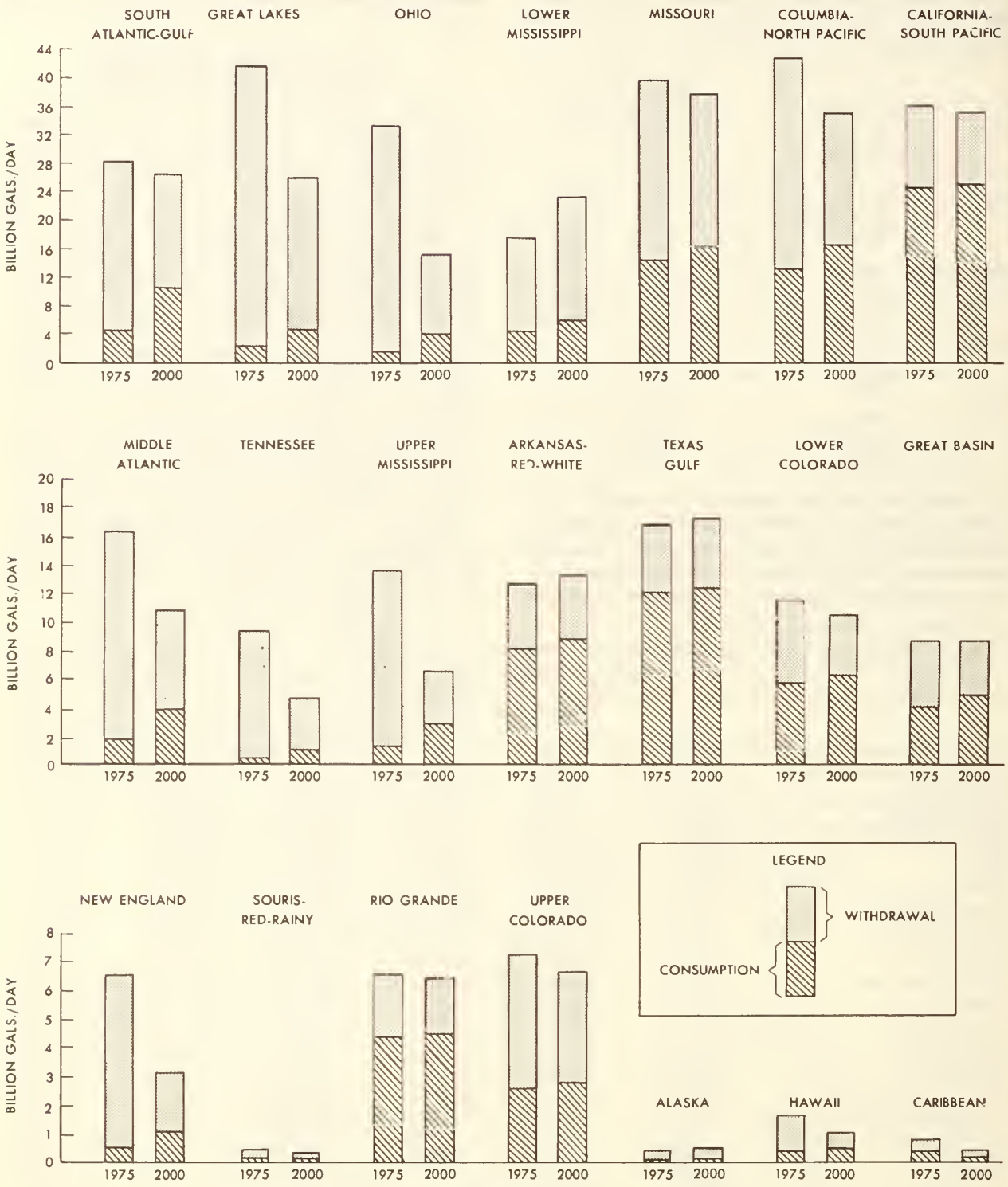

Figure 37

Projected withdrawals remain relatively stable or decline slightly in all the other Regions except the Lower Mississippi, Arkansas-Red-White, and Texas Gulf. The projected rise in these Regions largely reflects projected increases in withdrawals for steam electric cooling.

There are also wide variations among Regions in water withdrawals by major uses (tables 83–90). The Western Regions (including the Missouri) accounted for more than 90 percent of all water withdrawn for irrigation in 1975. Most of the remaining irrigation withdrawals were in the Arkansas-White-Red, Texas Gulf, and the Lower Colorado Regions. Irrigation withdrawals are projected to decline in many Regions as a result of increased efficiency in use. The largest projected increase is expected in the South Atlantic Gulf Region where irrigation of soybean and cotton is expected to increase substantially (table 83).

The largest withdrawals for steam electric cooling were in the Great Lakes, Ohio, and South Atlantic Gulf Regions (table 84). As a result of increased use of dry cooling towers, withdrawals for electric power cooling are projected to decrease significantly in many Regions. However, demands are projected to increase in the Lower Mississippi, Missouri, Arkansas-White-Red, Texas Gulf, Lower Colorado, and some other Regions to a minor degree.

Water withdrawals for manufacturing were largest in the Great Lakes, Ohio, and Middle Atlantic Regions in 1975 (table 85). These Regions along with the South Atlantic Gulf and the Lower Mississippi Regions accounted for over 70 percent of the water withdrawn for manufacturing. Water withdrawals for manufacturing in most Regions are projected to decline substantially because of the expected installation of recycling systems to reduce pollution to meet environmental standards. The biggest drop is in the Great Lakes Region where withdrawals fall from 12.8 billion gallons per day in 1975 to 2.7 billion gallons per day in 2000.

The largest withdrawals of water for domestic use (central supply systems and from noncentral systems combined) were in the Middle Atlantic Region with its urban corridor from Boston to Washington, D.C. (table 86). Other Regions with large withdrawals included the South Atlantic Gulf, Great Lakes, Ohio, and the California South Pacific. These Regions accounted for more than 60 percent of U.S. domestic withdrawals. The projections indicate that withdrawals in all Regions will increase, with the California-South Pacific and the Great Lakes Regions nearly doubling by 2000.

Withdrawals for mineral processing such as petroleum production and mining are currently largest in the Texas Gulf and the Lower Mississippi Regions (table 87). Increases in withdrawals for mineral processing are expected in all Regions, with the most significant increases in the South Atlantic Gulf and the Great Lakes Regions. Extensive development of coal and oil resources could result in very large increases in demand in the Missouri and Upper Colorado Regions.

Water withdrawals for livestock stock use were biggest in the Missouri, Arkansas-White-Red, and Upper Mississippi Regions (table 88). Demand in all Regions shows some increase although the totals involved are small relative to most other uses.

Withdrawals for use on public lands and in hatcheries is small and concentrated in the western Regions (tables 89 and 90). The projections show small increases in all Regions.

Consumptive Use of Water by Major Use

A high proportion of water that is withdrawn for most uses is returned to a water source for reuse. For example, out of 51.0 billion gallons per day withdrawn in 1975 for manufacturing purposes, about 45 billion gallons, or 88 percent, was returned to a water source. Total consumptive use in the United States in 1975 is estimated at 112 billion gallons per day (table 91). This represented about 30 percent of the water withdrawn for all uses.

Agricultural irrigation was by far the largest consumptive use of water in 1975. About 93 billion gallons per day, or 83 percent of all water used consumptively, was for irrigation. Domestic use was the next largest use with consumption amounting to 6.0 billion gallons per day. In addition to drinking and sanitation, domestic use includes water used for fire protection, street flushing, and lawn and garden irrigation. This represented about 5 percent of the total consumptive use. Manufacturing consumption of water was the third most important use, with a total volume of 5.9 billion gallons per day in 1975. Consumptive use in steam electric cooling, is small, amounting to only 1.3 billion gallons a day in 1975. This use and all other uses combined accounted for the remaining 6 percent of the total consumptive use.

In contrast to the decline in withdrawals, consumptive use of irrigation water is projected to increase slightly to 96.5 billion gallons per day by 2000 (table 91). Irrigation is expected to become much more widespread, especially in some of the more humid regions where it is not commonly practiced today. This projection (medium level) could be conservative if U.S. agricultural exports increase much faster than indicated by current trends. Much of the current consumptive use is due to losses in transmission of water from the source to the crop via evaporation and phreatophyte use. In making the projections of future demands, it was assumed that

Table 83. *Water withdrawals for irrigation in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(Million gallons a day)

Region	1975	1980	1990	2000	2010	2020
New England	25.2	27.4	31.5	35.3	39.5	43.5
Middle Atlantic	327.3	390.1	500.7	596.2	573.9	551.6
South Atlantic-Gulf	3,955.5	4,255.0	4,736.1	5,099.3	4,908.5	4,717.7
Great Lakes	175.5	215.5	283.4	339.5	326.8	314.1
Ohio	59.0	72.6	96.1	116.0	111.7	107.4
Tennessee	16.5	18.5	21.6	24.0	23.1	22.3
Upper Mississippi	178.6	226.8	308.8	376.5	362.4	348.3
Lower Mississippi	5,067.8	5,077.3	5,051.3	4,981.0	4,794.6	4,608.2
Souris-Red-Rainy	32.0	74.3	185.1	304.5	406.5	517.3
Missouri	32,064.3	35,656.9	37,610.8	37,821.0	41,518.7	43,472.6
Arkansas-White-Red	10,375.1	10,333.2	10,049.3	9,698.6	9,481.4	9,197.4
Texas-Gulf	12,004.4	10,864.5	8,744.5	6,677.7	4,504.4	2,384.4
Rio Grande	8,659.9	8,807.5	8,996.0	9,148.8	9,372.8	9,561.3
Upper Colorado	8,018.4	8,597.2	8,634.7	8,765.3	9,309.4	9,546.8
Lower Colorado	8,336.3	7,844.1	7,176.6	6,614.7	5,841.6	5,174.0
Great Basin	11,870.4	10,557.1	9,254.4	8,393.0	6,649.0	5,346.3
Columbia-North Pacific	40,801.5	43,084.1	41,803.1	38,573.3	39,241.0	37,960.0
California-So. Pacific	37,385.0	35,162.6	31,739.5	28,657.0	24,893.4	21,470.2
Alaska	5.8	5.8	5.8	5.8	5.8	5.8
Hawaii	1,273.9	1,137.1	912.2	735.9	708.8	680.8
Caribbean	746.6	712.8	571.8	357.5	344.0	330.6
Total	181,379.0	183,120.4	176,713.3	167.320.9	163,417.3	156,360.6

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 84. *Water withdrawals for steam electric cooling in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(Million gallons a day)

Region	1975	1980	1990	2000	2010	2020
New England	1,764.2	1,550.0	800.0	361.5	250.0	200.0
Middle Atlantic	5,957.0	5,288.8	3,798.1	2,256.0	816.7	673.9
South Atlantic-Gulf	14,941.1	13,147.4	11,682.8	10,925.8	8,753.6	7,298.0
Great Lakes	22,339.0	22,033.8	19,541.1	16,421.0	14,555.7	12,063.1
Ohio	22,153.0	20,048.2	14,855.9	9,336.0	4,471.3	3,000.0
Tennessee	6,715.0	5,879.7	4,642.6	3,550.0	2,168.4	1,000.0
Upper Mississippi	8,604.0	7,688.9	5,633.1	3,502.0	1,521.4	1,000.0
Lower Mississippi	4,279.0	6,524.7	10,771.6	14,927.0	19,265.4	23,512.3
Souris-Red-Rainy	132.0	86.0	20.0	0	0	0
Missouri	4,110.0	5,072.9	5,345.5	5,067.0	5,890.6	6,163.2
Arkansas-White-Red	236.0	486.7	692.6	800.0	1,104.4	1,310.3
Texas-Gulf	314.0	495.0	1,031.3	1,742.0	1,742.0	1,742.0
Rio Grande	11.0	10.0	7.7	5.0	5.0	5.0
Upper Colorado	69.0	93.0	122.0	132.0	132.0	132.0
Lower Colorado	51.0	95.0	134.7	126.0	126.0	126.0
Great Basin	35.0	49.5	62.0	58.0	58.0	58.0
Columbia-North Pacific	813.0	500.0	450.0	495.0	575.0	650.0
California-So. Pacific	52.0	100.0	205.0	314.0	416.3	521.7
Alaska	12.0	12.0	15.3	22.0	22.0	22.0
Hawaii	0	0	0	0	0	0
Caribbean	0	0	0	0	0	0
Total	92,587.3	89,161.6	79,811.3	70,040.3	61,873.8	59,477.5

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 85. *Water withdrawals for manufacturing in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	2,143.0	1,637.8	1,107.3	736.6	500.0	400.0
Middle Atlantic	5,311.7	4,190.5	2,981.2	2,116.3	562.6	500.0
South Atlantic-Gulf	4,433.4	3,913.1	3,413.7	3,094.7	2,414.9	1,915.5
Great Lakes	12,781.9	6,000.0	3,200.0	2,700.4	2,500.0	2,000.0
Ohio	10,621.3	6,000.0	2,800.0	2,292.6	2,000.0	1,800.0
Tennessee	1,974.2	1,400.0	600.0	564.5	400.0	400.0
Upper Mississippi	2,222.6	1,500.0	800.0	776.9	600.0	500.0
Lower Mississippi	4,086.1	2,200.0	1,300.0	1,269.7	1,000.0	900.0
Souris-Red-Rainy	100.7	75.7	38.0	30.6	25.0	20.0
Missouri	690.9	534.0	305.0	298.0	250.0	225.0
Arkansas-White-Red	633.1	547.2	479.3	446.0	343.5	275.5
Texas-Gulf	1,936.0	2,136.1	2,280.1	2,340.7	2,570.7	2,715.5
Rio Grande	291.9	175.0	36.0	32.6	30.0	30.0
Upper Colorado	4.0	3.0	2.0	2.0	2.0	2.0
Lower Colorado	143.5	138.7	149.1	166.4	170.2	180.1
Great Basin	111.3	103.2	98.6	97.8	89.3	84.7
Columbia-North Pacific	2,563.0	2,162.9	1,760.9	1,491.4	956.6	554.5
California-So. Pacific	664.1	721.2	774.8	808.1	881.9	935.4
Alaska	114.2	105.0	99.8	99.8	99.8	99.8
Hawaii	184.9	165.5	137.3	112.6	80.8	52.7
Caribbean	0	0	0	0	0	0
Total	51,011.8	33,708.9	22,363.1	19,477.7	15,477.3	13,590.7

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 86. *Water withdrawals for domestic use in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	718.4	849.8	1,005.8	1,126.2	1,317.8	1,473.8
Middle Atlantic	4,012.8	4,304.9	5,202.6	6,204.7	6,997.9	7,895.5
South Atlantic-Gulf	2,586.2	2,872.0	3,414.3	3,927.4	4,006.0	4,163.3
Great Lakes	3,264.9	3,560.6	3,851.6	4,042.5	4,433.7	4,724.7
Ohio	1,739.8	1,843.7	2,030.7	2,196.9	2,262.9	2,328.8
Tennessee	270.4	299.1	349.8	393.8	405.7	417.5
Upper Mississippi	1,124.1	1,186.8	1,300.6	1,402.7	1,444.9	1,487.0
Lower Mississippi	592.3	622.3	672.2	712.3	733.7	755.1
Souris-Red-Rainy	55.5	56.6	57.8	58.2	60.0	61.7
Missouri	869.7	883.2	947.7	1,050.0	1,081.5	1,113.0
Arkansas-White-Red	655.0	687.1	744.0	793.9	817.8	841.6
Texas-Gulf	1,207.7	1,292.4	1,457.1	1,620.5	1,786.8	1,951.6
Rio Grande	217.5	225.5	239.2	252.1	266.5	280.2
Upper Colorado	72.0	74.9	79.8	84.5	89.7	94.7
Lower Colorado	413.3	461.2	554.3	644.8	664.2	683.5
Great Basin	293.4	318.3	365.4	410.0	422.3	434.6
Columbia-North Pacific	879.2	910.7	975.7	1,042.8	1,074.1	1,105.4
California-So. Pacific	3,003.5	3,189.2	3,537.7	3,878.5	4,234.6	4,583.1
Alaska	97.9	110.7	135.6	160.0	164.8	169.6
Hawaii	123.1	132.8	151.7	170.4	189.5	208.4
Caribbean	0	0	0	0	0	0
Total	22,196.7	23,881.8	27,073.6	30,172.2	32,454.4	34,773.1

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 87. *Water withdrawals for mineral processing in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*
(Million gallons a day)

Region	1975	1980	1990	2000	2010	2020
New England	88.8	102.0	127.5	152.1	168.0	183.8
Middle Atlantic	459.0	414.3	598.6	699.0	771.9	844.7
South Atlantic-Gulf	943.1	1,086.4	1,371.3	1,655.6	1,941.0	2,225.9
Great Lakes	696.6	763.7	901.9	1,044.3	1,153.1	1,261.9
Ohio	549.9	584.1	640.9	686.1	757.6	829.1
Tennessee	111.3	124.1	151.1	179.7	198.5	217.2
Upper Mississippi	340.4	358.1	409.5	466.2	512.3	563.6
Lower Mississippi	1,025.0	1,101.4	1,292.9	1,523.1	1,681.8	1,840.5
Souris-Red-Rainy	8.4	8.5	9.2	10.2	10.5	10.8
Missouri	340.5	373.5	441.0	510.1	513.3	616.4
Arkansas-White-Red	546.0	568.4	616.6	668.4	738.1	807.7
Texas-Gulf	1,102.2	1,149.2	1,234.4	1,311.0	1,447.6	1,584.2
Rio Grande	262.8	263.5	265.7	268.8	296.8	324.8
Upper Colorado	126.3	135.3	156.2	180.0	198.8	217.5
Lower Colorado	423.3	486.0	617.6	755.4	834.1	912.8
Great Basin	181.2	200.0	238.6	278.4	307.4	336.4
Columbia-North Pacific	117.6	126.6	145.4	165.0	182.2	199.4
California-So. Pacific	121.8	131.7	152.5	173.3	192.5	210.0
Alaska	60.6	75.0	105.2	136.8	151.1	165.3
Hawaii	1.2	1.2	1.2	1.2	1.3	1.4
Caribbean	30.9	33.9	40.0	46.2	51.0	55.8
Total	7,536.9	8,086.9	9,517.3	10,910.9	12,108.9	13,409.2

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 88. *Water withdrawals for livestock in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(Million gallons a day)

Region	1975	1980	1990	2000	2010	2020
New England	18.2	18.3	18.4	18.5	18.6	18.7
Middle Atlantic	67.0	67.9	68.9	69.9	71.1	72.1
South Atlantic-Gulf	134.5	149.4	175.5	200.5	227.8	254.0
Great Lakes	83.4	84.1	85.5	87.0	88.4	89.9
Ohio	112.0	118.7	128.6	137.2	148.3	158.1
Tennessee	24.7	27.3	31.6	35.1	36.7	38.2
Upper Mississippi	229.7	253.0	281.2	303.2	337.5	365.7
Lower Mississippi	42.0	47.3	55.6	61.7	64.4	67.1
Souris-Red-Rainy	25.3	28.0	32.1	35.0	36.6	38.1
Missouri	408.2	451.9	519.1	579.8	653.8	721.1
Arkansas-White-Red	209.7	222.3	248.4	275.7	287.7	299.7
Texas-Gulf	174.4	180.4	197.7	220.2	229.8	239.4
Rio Grande	37.0	37.3	39.4	43.0	44.9	46.7
Upper Colorado	26.6	27.9	30.6	33.7	35.2	36.6
Lower Colorado	46.7	49.4	54.6	59.6	62.2	64.8
Great Basin	29.8	31.2	33.2	34.4	35.9	37.4
Columbia-North Pacific	68.1	76.4	89.0	97.8	102.1	106.3
California-So. Pacific	98.7	106.2	121.6	137.1	152.4	167.8
Alaska	.1	.2	.3	.3	.3	.3
Hawaii	2.2	2.3	2.6	2.9	3.1	3.2
Caribbean	5.9	7.1	9.1	10.8	11.3	11.7
Total	1,844.2	1,986.6	2,223.0	2,443.4	2,648.1	2,836.9

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 89. *Water withdrawals for public lands in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(Million gallons a day)

Region	1975	1980	1990	2000	2010	2020
New England	2.4	3.0	3.9	4.7	5.0	5.3
Middle Atlantic	5.5	6.5	8.3	9.8	10.4	11.0
South Atlantic-Gulf	9.9	12.1	15.9	19.3	20.5	21.6
Great Lakes	15.6	19.0	25.1	30.3	32.1	33.9
Ohio	11.0	13.3	17.5	21.1	22.3	23.6
Tennessee	2.9	3.5	4.6	5.7	6.1	6.4
Upper Mississippi	3.6	4.3	5.6	6.8	8.1	9.4
Lower Mississippi	5.4	5.5	6.1	7.2	7.2	7.8
Souris-Red-Rainy	3.1	3.1	3.6	4.1	4.4	4.8
Missouri	356.5	332.1	363.9	422.8	427.8	459.6
Arkansas-White-Red	32.7	37.7	45.2	50.4	53.4	56.3
Texas-Gulf	1.7	2.0	2.5	3.0	3.2	3.4
Rio Grande	22.4	24.8	27.7	28.7	30.4	32.1
Upper Colorado	119.7	128.7	140.8	146.8	155.4	164.1
Lower Colorado	24.3	41.5	61.5	67.2	71.2	75.1
Great Basin	360.5	379.1	419.8	463.7	491.0	518.3
Columbia-North Pacific	244.6	286.1	356.6	422.8	497.5	567.9
California-So. Pacific	371.7	375.4	386.2	400.3	423.9	447.5
Alaska	0	0	0	0	0	0
Hawaii	0	0	0	0	0	0
Caribbean	0	0	0	0	0	0
Total	1,593.5	1,677.7	1,894.8	2,114.7	2,269.9	2,448.1

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 90. *Water withdrawals for fish hatcheries in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(Million gallons a day)

Region	1975	1980	1990	2000	2010	2020
New England	36.9	46.3	55.6	55.6	58.4	61.3
Middle Atlantic	21.3	21.3	21.3	21.3	22.4	23.5
South Atlantic-Gulf	18.2	18.2	18.2	18.2	19.2	20.1
Great Lakes	21.6	23.7	26.6	28.2	29.6	31.1
Ohio	37.4	41.8	46.1	46.2	48.6	50.9
Tennessee	15.0	15.0	15.0	15.0	15.8	16.5
Upper Mississippi	4.4	5.0	5.6	6.3	6.6	6.9
Lower Mississippi	.1	.1	.1	.1	.1	.1
Souris-Red-Rainy	3.4	4.4	4.7	3.4	3.6	3.7
Missouri	46.8	46.9	47.1	47.3	49.7	52.1
Arkansas-White-Red	42.6	44.1	46.4	47.9	50.3	52.8
Texas-Gulf	17.1	14.3	11.5	11.5	12.1	12.7
Rio Grande	7.1	8.1	9.8	11.5	12.1	12.7
Upper Colorado	20.5	23.5	28.9	33.7	35.4	37.1
Lower Colorado	21.7	21.9	22.1	22.4	23.6	24.7
Great Basin	2.3	2.5	2.8	3.2	3.3	3.5
Columbia-North Pacific	271.1	286.2	305.4	313.7	329.7	345.7
California-So. Pacific	40.5	40.5	40.5	40.5	42.5	44.6
Alaska	0	0	0	0	0	0
Hawaii	0	0	0	0	0	0
Caribbean	0	0	0	0	0	0
Total	628.0	663.8	707.7	726.0	763.0	800.0

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

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Table 91. *Water consumption in the United States in 1975, by major use, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Major use	1975	1980	1990	2000	2010	2020
Domestic use	6,028.6	6,404.2	7,068.4	7,685.8	8,187.7	8,687.3
Manufacturing	5,936.6	7,487.2	11,449.0	14,698.9	19,373.1	23,334.7
Minerals	2,333.2	2,472.5	2,795.6	3,148.5	3,321.1	3,549.4
Crop irrigation	93,530.0	96,162.8	97,238.8	96,520.9	99,026.3	100.132.3
Livestock	1,851.8	1,993.5	2,228.4	2,451.6	2,667.3	2,871.0
Steam electric	1,294.8	2,593.0	5,750.3	9,140.6	11,770.2	14,577.5
Fish hatcheries	—	—	—	—	—	—
Public lands	1,428.8	1,560.6	1,736.3	1,986.5	2,172.5	2,451.6
Total	112,403.8	118,673.8	128,266.8	135,632.8	146,518.2	155,603.8

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

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Irrigation is by far the largest consumptive use of water and demand is likely to continue to grow.

substantial improvements in the efficiency of transmission and use would take place.

The manufacturing sector, as it increases output to meet growing demands, will require more water to support the growth in production. This additional consumptive requirement will be met in part by improved methods of water management including extensive recycling. Nonetheless, consumptive demand for water is projected to increase fairly rapidly nearly tripling by 2000 (table 91).

Domestic consumption is also expected to rise fairly rapidly—from 6.0 billion gallons a day in 1975 to 8.7 billion gallons in 2020. This increase is almost entirely the result of population growth.

Consumptive Use of Water by Region

There are large differences in the volume of water consumed in the Water Resource Regions (table 92, fig. 37). The largest use—28 billion gallons a day in 1975—was in the California-South Pacific Region. This represented about 25 percent of the Nation's total consumption. The Missouri Region was second with 14.4 billion gallons per day, slightly more than half of the use in the California-South Pacific. The consumptive use in the Columbia-North Pacific, Texas Gulf, Lower Colorado, and the Arkansas-White-Red Regions was also substantial. These Regions combined accounted for about 70 percent of the U.S. water consumption.

The concentration of use in the above Regions primarily reflected irrigation demands. For example, in the California-South Pacific Region, irrigation use amounted to more than 26 billion gallons per day in 1975. Irrigation use in the Missouri, Columbia-North Pacific, Texas Gulf, Arkansas-White-Red, Rio Grande, and Lower Colorado Regions was also large.

Projections of the Water Resources Council indicate that the consumptive use of water will rise in most Regions. Consumptive demand in the California-South Pacific Region is projected to decrease only slightly from 28.2 billion gallons a day in 1975 to 26.2 billion gallons in 1990. The projections for the Texas Gulf and Lower Colorado Regions also show only minor decreases in consumptive demand. Significant increases are projected for the South Atlantic Gulf and the Columbia-North Pacific Regions.

Projections of water consumption by major use and by Region are shown in tables 93 through 99. Projections of irrigation consumptive demands (table 93) show a significant increase is likely in the South Atlantic Gulf Region where demand increases

Table 92. *Water consumption in the United States in 1975, by Water Resource Region, with projections of demand to 2020*

(*Million gallons a day*).

Region	1975	1980	1990	2000	2010	2020
New England	456.5	533.3	737.5	954.7	1,132.4	1,328.3
Middle Atlantic	1,826.2	2,165.1	2,878.8	3,593.7	4,215.7	4,855.0
South Atlantic-Gulf	5,178.6	5,978.5	7,793.9	9,683.1	11,326.0	13,039.4
Great Lakes	2,544.7	2,881.3	3,653.2	4,452.5	5,153.8	5,890.3
Ohio	1,784.2	2,168.4	3,048.4	3,976.4	4,798.8	5,670.1
Tennessee	307.7	462.9	737.8	999.5	1,275.9	1,541.4
Upper Mississippi	1,039.1	1,284.2	1,882.9	2,508.6	3,021.1	3,574.2
Lower Mississippi	4,527.3	4,831.9	5,458.9	6.061.8	6,768.1	7,547.1
Souris-Red-Rainy	87.0	127.2	230.3	339.5	436.5	540.5
Missouri	14,376.7	16,156.1	18,012.0	19,298.9	21,714.7	23,563.6
Arkansas-White-Red	8,225.8	8,418.0	8,588.9	8,687.2	8,924.3	9,090.4
Texas Gulf	11,406.9	10,860.4	10,183.0	9,725.7	8,663.6	7,699.3
Rio Grande	6,133.3	6,401.9	6,785.6	7,117.1	7,561.6	7,955.6
Upper Colorado	2,669.7	3,080.5	3,700.1	3,777.4	4,287.6	4,671.5
Lower Colorado	4,626.4	4,593.7	4,595.4	4,593.9	4,491.6	4,424.1
Great Basin	4,289.6	4,685.7	5,096.3	5,486.0	6,003.6	6,421.7
Columbia-No. Pacific	13,773.6	15,885.6	17,722.5	18,901.0	21,518.2	23,367.2
California-So. Pacific	28,196.8	27,186.2	26,189.3	24,546.9	24,183.1	23,268.3
Alaska	79.3	101.0	142.8	184.2	211.0	237.3
Hawaii	464.0	468.0	485.7	508.9	575.5	644.2
Caribbean	410.4	403.9	343.5	235.8	255.1	274.3
Total	112,403.8	118,673.8	128,266.8	135,632.8	146,518.2	155,603.8

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 93. *Water consumption for irrigation in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	18.3	21.2	22.5	24.7	27.5	30.0
Middle Atlantic	241.2	287.2	368.2	438.3	474.9	511.5
South Atlantic-Gulf	3,146.5	3,324.2	3,691.7	4,071.2	4,411.4	4,751.5
Great Lakes	137.8	171.3	230.1	280.9	304.4	327.8
Ohio	44.5	54.8	73.1	90.6	109.7	128.0
Tennessee	12.4	13.9	16.5	18.8	20.4	21.9
Upper Mississippi	139.7	180.4	251.4	312.1	338.2	364.2
Lower Mississippi	3,426.8	3,520.0	3,644.9	3,708.6	4,018.5	4,328.3
Souris-Red-Rainy	25.7	60.0	149.9	246.8	329.6	419.4
Missouri	13,243.4	14,855.9	16,334.8	17,231.6	19,292.5	20,771.4
Arkansas-White-Red	7,313.2	7,370.6	7,289.2	7,141.7	7,126.4	7,045.0
Texas-Gulf	9,847.0	8,931.8	7,211.4	5,527.6	3,770.5	2,050.1
Rio Grande	5,840.9	6,101.0	6,470.6	6,790.0	7,209.8	7,579.4
Upper Colorado	2,426.7	2,803.2	3,367.9	3,405.3	3,897.3	4,262.1
Lower Colorado	4,144.5	4,042.3	3,921.1	3,827.6	3,678.7	3,557.4
Great Basin	3,692.8	4,017.5	4,365.2	4,612.4	5,060.7	5,408.4
Columbia-North Pacific	12,880.0	14,715.5	16,000.0	16,636.1	18,758.1	20,105.7
California-So. Pacific	26,128.9	24,893.5	23,117.3	21,572.7	19,565.0	17,788.8
Alaska	3.6	3.6	3.6	3.6	3.9	4.2
Hawaii	415.8	402.8	380.5	361.6	391.8	422.0
Caribbean	400.3	392.1	328.9	218.7	237.0	255.2
Total	93,530.0	96,162.8	97,238.8	96,520.9	99,026.3	100,132.3

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 94. *Water consumption for steam electric cooling in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	18.0	23.7	78.9	148.7	189.3	244.5
Middle Atlantic	84.0	146.6	329.7	532.0	695.8	878.8
South Atlantic-Gulf	184.8	444.1	1,044.8	1,672.9	2,246.2	2,847.0
Great Lakes	169.0	329.0	769.2	1,249.0	1,649.5	2,089.7
Ohio	295.0	455.8	884.6	1,349.0	1,742.0	2,170.8
Tennessee	53.0	145.1	281.5	402.0	554.3	690.7
Upper Mississippi	135.0	261.7	624.2	1,023.0	1,349.1	1,711.6
Lower Mississippi	44.0	78.6	160.7	247.0	324.8	406.8
Souris-Red-Rainy	1.0	0	0	0	0	0
Missouri	49.0	132.8	338.1	556.0	748.7	954.1
Arkansas-White-Red	49.0	123.1	250.9	372.0	506.6	634.5
Texas-Gulf	85.0	168.0	453.3	858.0	858.0	858.0
Rio Grande	8.0	7.0	5.3	4.0	4.0	4.0
Upper Colorado	25.0	46.0	72.7	84.0	84.0	84.0
Lower Colorado	44.0	77.5	106.7	98.0	98.0	98.0
Great Basin	5.0	30.0	40.0	40.0	41.0	42.0
Columbia-North Pacific	13.0	57.3	171.8	295.0	400.8	515.4
California-So. Pacific	32.0	64.7	134.2	205.0	273.1	342.6
Alaska	1.0	2.0	3.7	5.0	5.0	5.0
Hawaii	0	0	0	0	0	0
Caribbean	0	0	0	0	0	0
Total	1,294.8	2,593.0	5,750.3	9,140.6	11,770.2	14,577.5

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 95. *Water consumption for manufacturing in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	215.2	270.8	393.8	520.9	640.0	763.1
Middle Atlantic	615.1	794.3	1,147.5	1,499.0	1,853.9	2,207.0
South Atlantic-Gulf	798.8	1,038.5	1,670.9	2,354.2	2,935.6	3,567.9
Great Lakes	1,454.8	1,569.9	1,771.0	1,962.2	2,173.0	2,374.0
Ohio	787.2	951.1	1,328.2	1,721.7	2,082.4	2,459.4
Tennessee	134.4	187.8	306.6	429.5	544.3	663.2
Upper Mississippi	259.7	302.3	419.3	546.8	653.2	770.1
Lower Mississippi	260.4	382.5	678.6	991.9	1,270.7	1,566.7
Souris-Red-Rainy	4.1	7.6	15.3	23.3	30.7	38.5
Missouri	136.2	133.8	164.8	207.8	226.9	257.9
Arkansas-White-Red	159.6	191.5	260.6	331.6	398.6	468.1
Texas-Gulf	378.7	612.4	1,269.9	1,990.7	2,584.8	3,242.3
Rio Grande	9.1	11.7	17.8	24.3	30.1	36.2
Upper Colorado	1.9	1.7	3.9	7.1	8.4	10.7
Lower Colorado	107.8	94.6	103.7	124.7	122.0	131.1
Great Basin	20.4	30.0	52.7	76.4	97.9	120.5
Columbia-North Pacific	322.4	499.0	835.7	1,166.9	1,509.1	1,845.8
California-So. Pacific	237.4	349.5	896.0	550.8	1,989.2	2,535.7
Alaska	27.1	38.1	58.9	79.4	100.6	121.4
Hawaii	6.3	20.1	53.8	89.7	121.4	155.1
Caribbean	0	0	0	0	0	0
Total	5,936.6	7,487.2	11,449.0	14,698.9	19,373.1	23,334.7

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 96. *Water consumption for domestic use in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	172.9	182.7	200.5	216.5	230.2	243.9
Middle Atlantic	744.5	788.0	868.8	943.6	1,003.3	1,063.0
South Atlantic-Gulf	722.0	797.5	939.8	1,073.4	1,141.3	1,209.1
Great Lakes	531.8	549.7	590.4	632.9	672.0	712.7
Ohio	368.6	399.3	422.0	443.5	467.0	489.6
Tennessee	59.6	64.4	71.7	76.8	81.7	86.5
Upper Mississippi	219.8	226.7	236.4	242.3	257.7	273.0
Lower Mississippi	258.4	269.8	287.6	300.4	319.4	338.4
Souris-Red-Rainy	24.8	25.1	25.4	25.0	26.6	28.2
Missouri	247.8	256.1	269.8	280.7	295.6	310.4
Arkansas-White-Red	242.1	252.4	270.1	285.0	303.1	321.1
Texas-Gulf	403.2	433.9	488.4	540.6	597.4	651.9
Rio Grande	109.5	113.7	120.6	126.1	134.1	142.1
Upper Colorado	24.8	25.7	27.3	28.7	30.5	32.3
Lower Colorado	196.8	219.7	264.0	306.9	326.3	345.7
Great Basin	129.6	140.2	160.0	178.6	189.9	201.2
Columbia-North Pacific	224.7	231.1	243.3	254.9	271.1	287.2
California-So. Pacific	1,288.5	1,363.4	1,506.8	1,644.0	1,748.1	1,852.1
Alaska	19.5	22.0	26.7	31.2	33.2	35.1
Hawaii	39.7	42.8	48.8	54.7	59.2	63.8
Caribbean	0	0	0	0	0	0
Total	6,028.6	6,404.2	7,068.4	7,685.8	8,187.7	8,687.3

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 97. *Water consumption for mineral processing in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	11.5	13.7	19.6	20.7	21.8	22.8
Middle Atlantic	69.6	75.5	88.3	102.3	107.5	112 7
South Atlantic-Gulf	182.1	203.3	247.2	291.6	335.0	378.9
Great Lakes	152.3	158.4	182.3	210.2	230.2	254.1
Ohio	165.9	175.4	194.7	213.3	224.2	235.1
Tennessee	18.9	20.9	25.3	30.2	31.8	33.3
Upper Mississippi	51.6	55.7	64.6	74.4	78.2	82.0
Lower Mississippi	490.5	528.0	624.8	743.4	755.4	819.4
Souris-Red-Rainy	3.0	2.8	2.9	3.3	3.5	3.7
Missouri	106.5	113.7	128.8	144.5	151.5	158.4
Arkansas-White-Red	217.2	219.3	224.5	230.8	242.6	254.4
Texas-Gulf	516.9	531.9	559.8	585.6	615.6	645.6
Rio Grande	106.5	106.8	105.1	101.1	106.3	111.4
Upper Colorado	45.0	47.3	56.9	71.8	75.5	79.1
Lower Colorado	63.6	72.6	91.8	112.2	118.0	123.7
Great Basin	52.4	58.1	69.4	80.5	84.6	88.7
Columbia-North Pacific	17.4	18.2	20.8	24.6	25.9	27.1
California-So. Pacific	30.1	31.1	33.7	37.0	38.9	40.8
Alaska	28.0	35.1	49.6	64.7	68.0	71.3
Hawaii	0	0	0	0	0	0
Caribbean	4.2	4.7	5.5	6.3	6.6	6.9
Total	2,333.2	2,472.5	2,795.6	3,148.5	3,321.1	3,549.4

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 98. *Water consumption for livestock in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	18.2	18.2	18.3	18.5	18.6	18.7
Middle Atlantic	67.0	67.7	68.9	69.9	71.1	72.3
South Atlantic-Gulf	134.5	160.0	184.6	200.5	233.9	258.5
Great Lakes	83.4	84.1	85.5	87.0	88.4	89.8
Ohio	112.0	118.7	128.5	137.2	148.2	158.0
Tennessee	26.5	27.3	31.6	36.5	37.3	39.4
Upper Mississippi	229.7	253.0	281.1	303.2	337.5	365.6
Lower Mississippi	43.7	48.5	56.3	63.4	71.8	79.5
Souris-Red-Rainy	26.0	28.9	33.2	37.0	41.8	46.1
Missouri	408.2	451.8	519.1	579.8	653.7	721.0
Arkansas-White-Red	209.7	222.3	248.4	275.7	293.1	310.5
Texas-Gulf	174.4	180.4	197.7	220.2	234.1	248.0
Rio Grande	37.0	37.3	39.4	43.0	45.7	48.4
Upper Colorado	26.6	27.9	30.6	33.7	35.9	38.0
Lower Colorado	46.7	49.4	54.6	59.6	63.4	67.1
Great Basin	29.8	31.2	33.2	34.4	36.6	38.7
Columbia-North Pacific	71.5	76.4	89.0	100.9	104.0	110.1
California-So. Pacific	98.7	100.8	116.4	137.1	137.3	145.5
Alaska	.1	.2	.3	.3	.3	.3
Hawaii	2.2	2.3	2.6	2.9	3.1	3.3
Caribbean	5.9	7.1	9.1	10.8	11.5	12.2
Total	1,851.8	1,993.5	2,228.4	2,451.6	2,667.3	2,871.0

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

Table 99. *Water consumption for public lands in the United States in 1975, by Water Resource Region, with projections of demand (medium level) to 2020*

(*Million gallons a day*)

Region	1975	1980	1990	2000	2010	2020
New England	2.4	3.0	3.9	4.7	5.0	5.3
Middle Atlantic	4.8	5.8	7.4	8.6	9.2	9.7
South Atlantic-Gulf	9.9	10.9	14.9	19.3	22.6	26.5
Great Lakes	15.6	18.9	24.7	30.3	36.3	42.2
Ohio	11.0	13.3	17.3	21.1	25.3	29.2
Tennessee	2.9	3.5	4.6	5.7	6.1	6.4
Upper Mississippi	3.6	4.4	5.9	6.8	7.2	7.7
Lower Mississippi	3.5	4.5	6.0	7.1	7.5	8.0
Souris-Red-Rainy	2.4	2.8	3.6	4.1	4.3	4.6
Missouri	185.6	212.0	256.6	298.5	345.8	390.4
Arkansas-White-Red	35.0	38.8	45.2	50.4	53.6	56.8
Texas-Gulf	1.7	2.0	2.5	3.0	3.2	3.4
Rio Grande	22.3	24.4	26.8	28.6	31.6	34.1
Upper Colorado	119.7	128.7	140.8	146.8	156.0	165.3
Lower Colorado	23.0	37.6	53.5	64.9	85.2	101.1
Great Basin	359.6	378.7	375.8	463.7	492.9	522.2
Columbia-North Pacific	244.6	288.1	361.9	422.6	449.2	475.9
California-So. Pacific	381.2	383.2	384.9	400.3	431.5	562.8
Alaska	0	0	0	0	0	0
Hawaii	0	0	0	0	0	0
Caribbean	0	0	0	0	0	0
Total	1,428.8	1,560.6	1,736.3	1,986.5	2,172.5	2,451.6

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

from 3.1 billion gallons a day in 1975 to 4.1 billion gallons in 2020. This growth largely reflects expectations on increased production and irrigation of soybeans in that area. A similar proportional increase is expected in the Columbia-North Pacific Region where more intensive irrigation is projected. The projections also show a substantive increase in the Missouri Region. Demands in the other major irrigating Regions, however, are to remain about the same or decline slightly over the projected period.

Projections of manufacturing consumptive use show significant increases in all Regions (table 95). For example, demand in the Columbia-North Pacific increases by almost four times by 2000, while that in the South Atlantic Gulf grows by three times. Demands in the Lower Mississippi, Texas Gulf, and Ohio Regions are all projected to increase by two to three times during the same period. Most of the increase in all Regions is due to increased use of evaporative cooling in the manufacturing process and incorporation of water into final products.

There are also fairly rapid increases in domestic demands in all Regions in response to population growth.

Prospective increases in demand in other consumptive uses are small and fairly uniformly spread among the Regions.

Instream Demand for Water

Not all water demands involve removing water from its source. Many uses depend upon the amount of water that is in the watercourse itself. These include hydroelectric power production, navigation, water based recreation, and flow requirements for aquatic habitat.

Very little data is available on important onsite and instream water uses even though these uses have grown to great importance in our society. Unfortunately, they are not measured by the more conventional types of data collection and analysis. This is especially true of water for esthetic and recreation purposes.

There are some indicators of the importance of flow and instream water use. For example, between

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Instream use of water for the transportation of heavy and bulky products such as oil, coal, wheat, and chemicals has been growing rapidly and is likely to continue to do so.

1950 and 1970, there was a fourfold increase in traffic moving on the Nation's inland waterways from 52 billion-ton-miles to 204 billion-ton-miles.[6]

Of the 255 million kilowatts in operation in 1965, 18 percent (or 44-1/2 million kilowatts) was in conventional and pumped storage by hydroelectric plants. However, except for Alaska, the sites available for conventional hydroelectric projects are relatively scarce, and there are increasingly difficult problems involved with their development, such as undesirable impacts on the environment and conflicts with the use of streams for other purposes.

The Supply of Water

Precipitation

The Nation's renewable water resources are derived from an average annual precipitation of 30 inches, or more than four trillion gallons per day in the contiguous United States. About 70 percent of this precipitation is consumed through evaporation and transpiration. The remaining 30 percent constitutes the Nation's average annual natural runoff of about 9 inches, or about 1,200 billion gallons per day.

The normal annual precipitation over the contiguous 48 States ranges from an average less than 4 inches in parts of the Great Basin and Lower Colorado Regions to more than 200 inches in coastal areas of the Columbia-North Pacific Region (fig. 38). About 26 inches of the total 30 is rain and the remaining 4 inches is snow or other frozen forms. The area east of the Mississippi River averages about 44 inches, the area west of the Rocky Mountains about 18 inches, and the intervening area about 28 inches.

In the Alaska Region, the normal annual precipitation ranges from about 5 inches in the extreme north to more than 200 inches along the southern panhandle, for an overall average of about 20 inches.

Within Regions, rainfall varies widely from season to season and even year to year. In general, the areas of least variability (more dependable supply) are in the Northwest, Northeast, and the Southeast. In con-

[6] U.S. Army Corps of Engineers, Annual report of the Chief of Engineers, Vol. 1, U.S. Government Printing Office, Washington, D.C. 1951; and the U.S. Army Corps of Engineers, Waterborne Commerce of the United States, calendar year 1970, Part 5, national summaries, U.S. Army Engineer District, New Orleans, La. 1972.

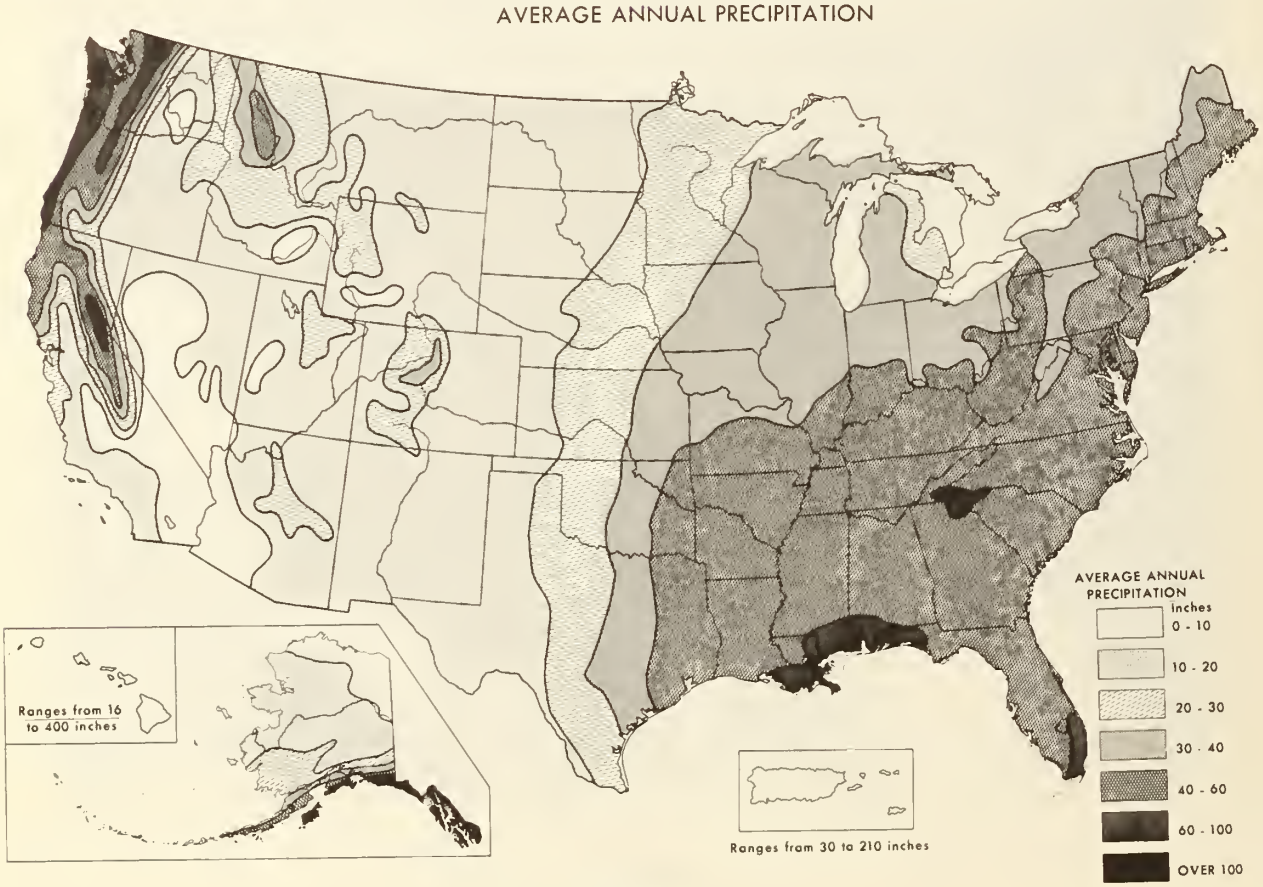

Figure 38

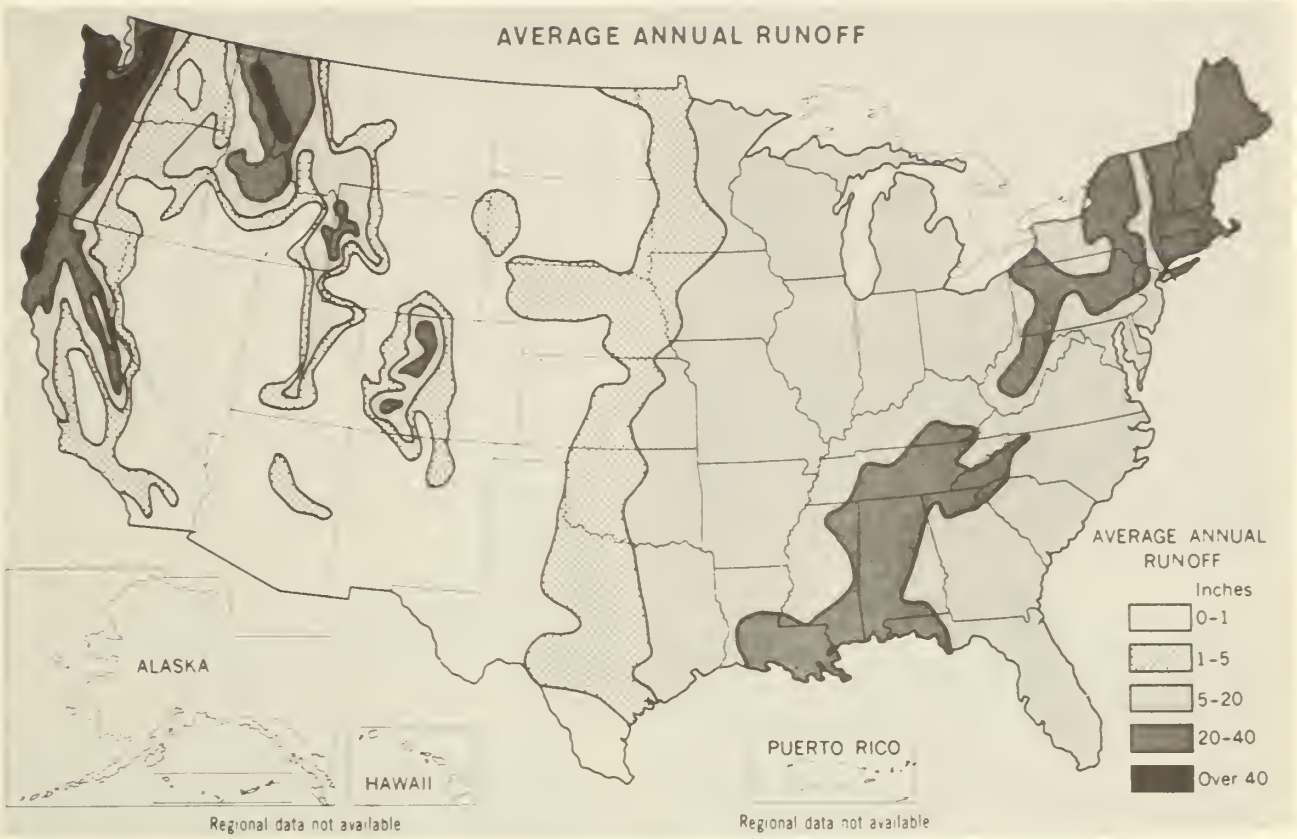

Figure 39

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More than 60 percent of the annual water runoff in the United States originates on forested lands. The resulting streams and lakes provide outdoor recreation for millions of people.

trast, the areas of greatest variability in precipitation are in the Southwest and North Central sections of the United States. Even in areas of high precipitation and runoff, a series of dry years sometimes occurs, resulting in serious drought problems such as those in the Northeast during 1961–66. The adverse effects of droughts are particularly felt in areas which are using a high proportion of their water supply each year or where storage and distribution facilities are inadequate to meet prolonged shortages or increased water requirements.

A large portion of the precipitation in the United States falls on forested land because forests are typically located at higher elevations, initially capturing and gradually releasing water to downstream areas. Also, forest and range vegetal cover normally provides excellent protection for streams because it maintains good water quality and helps to stabilize flow.

Surface Water

Streamflow provides most of the Nation's usable fresh water including nearly 70 percent of all withdrawals. Natural streamflow can be highly variable. Within a normal year, the ratio of maximum flow to minimum flow may be 500 to 1. Year to year variations may also be large. Because streamflow is dependent upon precipitation, evapotranspiration, and basin characteristics, the amount of water available from a stream varies greatly in different parts of the country.

Average annual runoff for the period 1931–60 is shown in figure 39. The lines show points of equal runoff at its place of origin where it first collects in the stream channel. The yield shown on the map does not show losses from evapotranspiration.

More than 60 percent of the annual natural runoff originates on forest land, even though it represents only about one-third of the area of the contiguous States. In the 11 Western States, over 90 percent of the usable water originates on high altitude watersheds which are typically forested.

Water Supplies by Region

Estimates of water supplies by Region are shown in table 100. These estimates are based primarily on adjusted natural runoff, which is the annual flow of water that would appear in surface streams, adjusted to account for upstream water development. In areas of surface water/ground water continuity, the adjusted natural runoff included the perennial recharge or yield of ground water aquifers.

These supply estimates are assumed to be relevant to the projected years since they are based on runoff data collected over several years. The data on supply (runoff) was computed from statistical distributions

Table 100. *Expected water supplies in the United States, by Water Resource Region*

(*Billion gallons a day*)

Region	Confidence level[1]	
	Mean	95 percent
New England	74.7	46.0
Middle Atlantic	91.0	56.2
South Atlantic-Gulf	227.8	121.6
Great Lakes	74.8	47.0
Ohio	240.0	138.6
Tennessee	68.9	52.0
Upper Mississippi	266.1	140.4
Lower Mississippi	1,196.7	749.6
Souris-Red-Rainy	6.0	18.3
Missouri	156.8	97.3
Arkansas-White-Red	778.0	30.7
Texas-Gulf	33.9	12.2
Rio Grande	58.1	40.0
Upper Colorado	24.6	13.7
Lower Colorado	10.6	10.2
Great Basin	72.4	13.1
Columbia-North Pacific	611.4	323.7
California-South Pacific	74.2	34.3
Alaska	905.0	704.6
Hawaii	6.2	3.3

[1] These data represent the average daily supply of water that would be exceeded on the average and in 95 percent of the years. For example, the New England region can expect an average daily water supply of 46.0 billion gallons a day or more in 95 out of 100 years.

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

of annual runoff at several hundred gauging stations throughout the United States by the U.S. Geological Survey. In areas where extensive water projects will be installed, the supply figures may be conservative.

Throughout most of the United States, the within-year cycle varies from the high flows during spring and early summer to the low flows during late summer to early winter. Many times the high water use season in a Region corresponds to the low water yield season. For this reason, the analysis of water supplies and demands on an average basis may not reveal some water shortage problems.

The mean annual runoff in the contiguous United States is about 1,200 billion gallons a day. The summary data in table 100 cannot be totaled to estimate total water supply for the United States because flows from upstream areas are included in downstream estimates. For example, the large estimate of waterflow in the Lower Mississippi includes water that is also available to and flows out of the Upper Mississippi, the Ohio, and the Arkansas-White-Red Regions. Therefore, while these data represent an estimate of water available in each Region, to total them would be double counting in many cases.

On this basis, the Lower Mississippi Region has the highest water supply potential in the contiguous United States, with its expected runoff exceeding 749 billion gallons a day in 95 percent of the years. The Region can expect to exceed one trillion gallons per day on the average. Much of this supply is exit flows from the vast upstream drainage of the Mississippi.

Alaska can expect its supply to exceed 700 billion gallons a day with 95 percent confidence, but this vast remotely located supply is not likely to be of much utility to the greatest majority of the people of the United States.

Users in the Columbia-North Pacific can expect flows in excess of 323 billion gallons a day with 95 percent confidence and 611 billion gallons a day on the average. Streams west of the Cascade Range are characterized by high winter flows and low summer flows.

The Ohio Region will have flows in excess of 138 billion gallons a day at the 95 percent level, while the Upper Mississippi Region can count on 140 billion a day with the same confidence. In the Upper Mississippi, extreme low flows generally occur in midwinter and midsummer. Runoff is generally lowest in the western part of the Region.

The South Atlantic-Gulf supply varies from 122 billion gallons a day at the 95 percent level to 228 billion gallons a day for the average year. The variability within the individual portions of the Region is high, ranging from 5 to 40 inches a year.

Water supply at the 95 percent level in the remaining Regions ranges from 18.3 billion gallons a day in the Souris-Red-Rainy to 97.3 billion gallons a day in the Missouri. This discussion does not imply relative importance to each Region's water supply, since many other factors are involved in determining water value. This discussion serves to point out the relationship of each Region in terms of water quantity (supply) only.

Ground Water

Ground water aquifers presently supply more than 20 percent of the Nation's withdrawal use of water. Ground water also provides the base flow of streams, and in some Regions ground water flows provide streams with a continuity of flow that they would not otherwise possess. The water supply information presented in the surface water section includes considerable water that enters from ground water aquifers. Part of this ground resource does not naturally get into the surface water supply, and can be developed only by drilling. Ground water is very difficult to inventory because of its limited access. It has been estimated that the total storage greatly exceeds the volume at all five Great Lakes. About one-half of the country is underlain by rock material that could yield at least 50 gallons per minute to wells.

The Atlantic and Gulf Coastal Plains contain the largest reserve of ground water in the Nation (fig. 40). Present pumpage is but a small fraction of the supplies that could be developed. However, saltwater encroachment along the Gulf and Atlantic coasts is a limiting factor in ground water development.

Perhaps the next most significant area for ground water potential is the series of alluvial basins in the Far West. These are alluvium-filled valleys surrounded by mountains from which they receive runoff recharge. The surface is very dry, but the alluvial deposits are usually very thick and they now store equivalent to centuries of recharge. In this area, conjunctive development of streamflow and ground water in storage is becoming a necessity, because of heavy water use for irrigation and domestic needs in large cities such as Los Angeles, Phoenix, and Alburquerque.

Still another area with important ground water potential is the area of glacial deposits in the Great Lakes area, extending from central Montana to eastern New York. The glacial deposits contain beds of watersorted permeable sand and gravel that constitute an important source of water.

The High Plains area has large quantities of ground water in storage. In the southern part of the Plains, irrigation pumpage from wells accounts for more than 10 percent of the Nation's total ground water pumpage. This area is a classic example of ground water mining, where withdrawals greatly exceed recharge. As the ground water table recedes, pumping costs go up because of greater pumping distance. At some point, it will become uneconomical to recover this ground water. Estimates on the life of the recoverable storage in the High Plains range from 10 to 50 years.

Prospective Water Problems

Two measures are generally used to assess the water demand-supply situation. These are: (1) Water quantity demanded and supplied and (2) water quality.

Water Quantity

Table 101 presents the water demand-supply data used to support this evaluation. Since water problems generally are localized in nature, this information is presented by aggregated subarea (defined on page 189). The proportion of each aggregated subarea that is currently in forest and range land is presented to indicate the importance of these lands as a source of water.

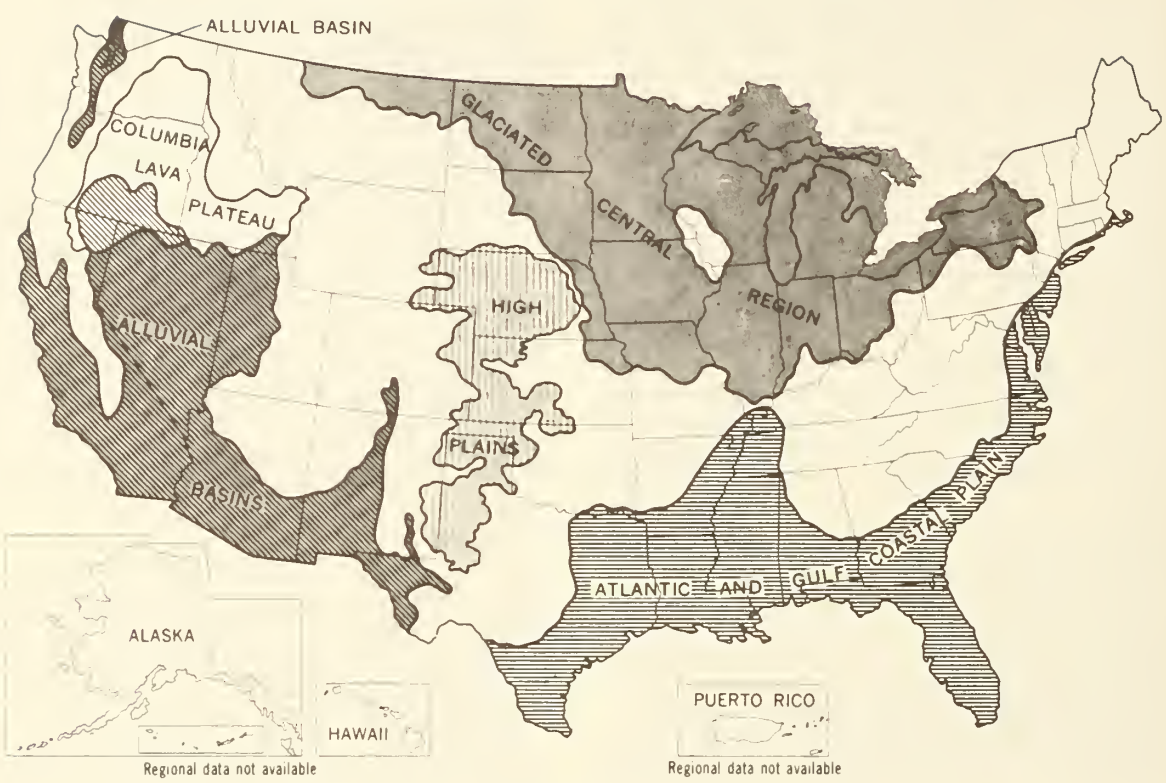

Figure 40

Consumptive water use is the value most often used to make water quantity assessments. It is difficult to measure the effect of water withdrawals on supply since a portion is returned to the stream and is available for reuse. The reduced quality of water returned may affect supply, but this will be discussed in the section on water quality.

The appraisal of water quantity is also usually related to water supplies at the 95 percent confidence level since this is generally the more critical level (shortage one year out of 20). The reader should keep in mind that severe water shortages could occur in small localized areas that will not show up at the aggregated subarea level. Also, the supply data is average daily supply on an annual basis and does not reflect seasonal shortages that might occur.[7]

In general, the eastern part of the United States is expected to have only a few water shortage problems at the aggregated subarea level. The New England and Middle Atlantic Regions show no aggregated subareas where water quantity problems are anticipated during the projected years. In most of these areas, consumptive use represents less than 10 percent of the 95 percent supply.

In the South Atlantic Gulf Region, the Southern Florida area (305) is expected to have water shortages at the 95 percent level of supply by 2000 and 2020.

Consumptive use in the Southern Lake Michigan (403) area of the Great Lakes Region is expected to exceed the 95 percent supply by 1985. In this area, it is anticipated that manufacturing and electric cooling activities will be major water consumers in the future.

The Upper Platte Basins (1007) and the Republican-Smoky-Hill-Blue-Kansas (1010), aggregated subareas in the Missouri Water Resource Region, would have a waste shortage in 1975 if water supplies were at the 95 percent level. These areas are likely to continue to have shortages to 2020. Ninety-four percent of the consumptive use in 1975 is for irrigation and will decrease to about 90 percent by 2000. Forest management practices could have important influence since 61 percent of 1007, and 36 percent of 1010, is forested.

In the South, there are several areas where water shortages are likely to occur. In nearly all of these areas, the current, as well as projected, requirements

[7] The Water Resources Council's 1975 Assessment of Water and Related Land Resources will contain a monthly comparison of supply and requirements that will aid in evaluating seasonal problems. These data were not available in time for this report.

Table 101. *Water demand-supply balances in the United States, by aggregated subarea, 1975, with projections to 2020*

(*Million gallons a day*)

Aggregated subarea	Water supplies[1]		Consumptive use projections (medium level)				Consumptive use equals or exceeds 95 percent supply				Percent of area in forest and range land
	Mean	95%	1975	1985	2000	2020	1975	1985	2000	2020	
New England											
101	38,444.6	24,741.8	84.0	120.4	193.7	218.7					88
102	9,791.1	5,589.8	30.7	40.2	53.2	60.1					83
103	4,298.2	2,229.8	103.7	137.4	196.7	222.1					57
104	1,753.5	409.1	83.7	107.3	141.5	159.8					66
105	12,223.1	7,698.6	285.9	309.8	483.6	546.1					79
106	8,178.6	5,334.6	25.5	31.2	41.9	47.3					72
Middle Atlantic											
201	12,922.8	8,721.4	882.4	911.3	1,028.8	1,161.8					64
202	14,576.1	9,017.4	531.3	643.5	799.7	903.1					23
203	15,858.7	9,330.4	1,218.4	1,398.8	1,629.4	1,840.0					48
204	24,529.4	17,031.6	284.7	363.8	514.5	581.0					59
205	14,421.3	7,893.1	278.2	451.5	619.1	699.1					51
206	8,715.1	4,255.2	132.1	220.7	505.4	570.7					51
South Atlantic-Gulf											
301	25,907.4	13,691.2	287.1	464.4	849.3	959.1					69
302	28,120.3	14,546.7	445.9	625.0	1,207.9	1,364.0					61
303	25,209.2	12,928.4	229.1	451.8	698.5	788.8					67
304	18,304.9	5,313.0	1,137.4	1,442.6	1,730.2	1,953.8					68
305	7,799.8	2,952.1	2,321.7	2,656.7	3,200.4	3,614.1			X	X	48
306	21,764.4	13,684.9	228.7	336.4	557.3	629.3					65
307	40,021.1	24,573.1	226.4	359.4	756.2	854.0					68
308	41,705.6	25,675.8	204.7	317.5	451.5	510.0					68
309	19,004.2	8,274.5	208.2	262.7	316.5	357.4					68
Great Lakes											
401	9,858.8	6,562.4	130.0	148.0	231.3	261.2					89
402	9,542.1	5,211.5	162.4	233.0	382.2	431.6					56
403	2,435.8	1,692.5	1,611.8	1,839.0	2,180.1	2,461.9		X	X	X	6
404	14,606.1	10,081.6	249.3	321.3	496.4	560.6					39
405	7,304.6	4,176.5	67.6	106.5	222.4	251.1					49
406	7,630.5	3,105.9	621.1	788.4	980.8	1,107.5					11
407	5,500.8	3,755.6	572.7	601.4	625.8	706.7					34
408	17,999.3	12,440.6	111.8	154.8	325.8	367.9					50
Ohio											
501	19,765.1	14,271.1	146.0	185.4	228.3	257.8					68
502	63,602.5	41,044.6	683.2	925.6	1,462.7	1,651.8					55
503	12,076.8	6,453.5	216.5	317.5	548.6	619.5					24
504	10,713.5	7,352.4	104.1	159.4	312.2	352.6					72
505	96,343.4	53,877.5	270.6	356.9	635.3	717.4					45
506	19,768.7	7,875.7	288.3	359.8	638.0	720.5					15
507	17,711.0	7,757.1	76.3	140.8	161.2	182.0					51
Tennessee											
601	23,248.4	15,686.0	214.4	376.6	577.2	651.8					57
602	45,664 7	36,465.4	4,022.6	4,184.7	4,350.5	4,912.8					49
Upper Mississippi											
701	9,905.9	3,054.5	251.0	326.0	400.8	452.6					29
702	26,396.0	15,020.1	175.7	219.0	355.6	401.6					43
703	42,499.7	19,533.2	330.0	475.7	826.7	933.5					8
704	61,018.6	32,061.7	206.9	353.7	702.4	793.2					10
705	126,367.2	70,780.2	193.5	237.7	340.6	384.6					31
Lower Mississippi											
801	337,220.4	210,533.8	1,661.8	1,943.8	2,137.5	2,413.8					27
802	401,107.0	261,105.4	840.1	1,030.7	1,303.0	1,471.4					58
803	458,547.0	277,954.0	2,025.4	2,141.2	2,621.8	2,960.7					46
Souris-Red-Rainy											
901	6,031.4	1,830.0	93.7	174.8	366.9	414 3					26
					.3	.3					25

[1] These data represent the average daily supply that would be expected in 50, 80, and 95 percent of the years.

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources.* op. cit.

Table 101. *Water demand-supply balances in the United States, by aggregated subarea, 1975, with projections to 2020—continued*

(*Million gallons a day*)

Aggregated subarea	Water supplies[1]		Consumptive use projections (medium level)				Consumptive use equals or exceeds 95 percent supply				Percent of area of forest and range land
	Mean	95%	1975	1985	2000	2020	1975	1985	2000	2020	
Missouri											
1001	8,789.1	5,880.4	358.4	660.4	671.8	758.6					46
1002	6,532.7	4,076.5	1,481.7	2,675.6	2,683.4	3,030.3					68
1003	8,147.6	5,432.9	634.4	779.1	785.3	886.8					71
1004	9,557.1	6,196.0	2,275.8	3,404.5	3,315.9	3,744.5					64
1005	20,299.7	12,608.0	1,656.5	2,175.6	2,491.0	2,813.0					59
1006	2,224.9	1,514.0	236.1	472.1	773.8	873.8					18
1007	2,710.8	2,187.3	3,637.8	3,482.8	3,863.5	4,362.9	X	X	X	X	61
1008	6,863.4	5,118.2	3,281.4	4,211.0	4,097.1	4,626.7					63
1009	33,829.0	26,913.0	158.2	205.7	266.5	300.9					7
1010	4,497.3	1,524.0	3,010.0	3,147.6	3,120.9	3,523.3	X	X	X	X	36
1011	53,363.7	25,893.4	299.7	368.8	481.0	543.2					29
Arkansas-White-Red											
1101	15,846.2	7,443.5	78.4	114.5	131.5	148.5					71
1102	750.9	654.6	1,020.2	743.0	708.8	700.4	X	X	X	X	65
1103	4,051.9	1,078.6	2,307.5	2,859.2	2,876.3	3,248.1	X	X	X	X	33
1104	26,770.5	8,220.0	483.3	685.2	986.3	1,113.8					55
1105	4,454.2	1,674.8	3,137.6	3,047.0	3,094.6	3,494.6	X	X	X	X	68
1106	4,067.3	2,968.5	3,596.0	3,756.0	3,548.5	4,007.2	X	X	X	X	56
1107	21,859.3	8,673.5	232.9	263.6	260.2	293.8					59
Texas-Gulf											
1201	10,318.8	3,402.7	557.1	604.3	1,040.2	1,174.7					62
1202	8,690.2	2,614.4	1,879.7	2,131.6	3,135.7	3,541.0			X	X	41
1203	6,653.9	2,711.1	6,223.2	5,041.2	3,277.1	3,700.7	X	X	X	X	47
1204	3,843.7	2,357.1	3,232.1	2,880.8	2,732.3	3,085.5	X	X	X	X	70
1205	4,413.5	1,117.0	1,405.6	1,451.6	1,358.8	1,534.4	X	X	X	X	72
Rio Grande											
1301	910.3	773.6	2,012.4	2,091.5	2,526.9	2,853.5	X	X	X	X	71
1302	959.9	740.2	1,354.7	1,434.2	1,390.6	1,570.8	X	X	X	X	67
1303	1,465.00	1,090.1	729.2	725.7	484.6	547.2		X	X	X	93
1304	322.4	204.1	664.6	456.1	484.4	547.0	X	X	X	X	74
1305	2,208.1	1,173.9	2,261.8	3,141.8	3,418.8	3,860.7	X	X	X	X	83
Upper Colorado											
1401	4,853.2	2,849.5	1,348.2	1,999.8	1,846.6	2,085.3					46
1402	6,386.7	3,542.7	1,488.3	1,647.4	1,800.0	2,032.7					46
1403	13,359.5	7,283.7	1,221.0	2,140.4	2,363.2	2,668.7					48
Lower Colorado											
1501	345.0	241.6	122.0	114.2	222.9	251.7				X	86
1502	10,609.0	10,305.2	6,642.7	6,277.7	6,586.6	7,438.0					31
1503	-354.2	-374.2	3,666.8	3,637.8	3,496.0	3,947.9	X	X	X	X	71
Great Basin											
1601	3,243.7	501.2	1,509.8	1,688.6	1,793.0	2,024.8		X	X	X	48
1602	894.0	276.1	702.1	758.2	765.7	864.7	X	X	X	X	39
1603	1,606.8	-168.2	1,396.4	1,909.6	2,046.8	2,311.4	X	X	X	X	22
1604	1,500.2	696.7	952.2	1,124.8	1,214.8	1,371.8	X	X	X	X	15
Columbia-North Pacific											
1701	32,093.8	18,074.2	1,169.0	1,778.2	1,816.6	2,051.4					86
1702	122,814.2	90,470.3	4,885.6	6,230.4	6,542.1	7,387.8					67
1703	13,820.6	8,850.1	7,346.4	9,093.3	8,159.9	9,371.4		X	X	X	43
1704	33,353.5	23,832.7	624.8	899.0	1,070.7	1,209.1					77
1705	219,876.8	158,071.9	860.1	1,510.5	1,821.0	2,056.4					75
1706	34,327.4	24,030.9	175.2	306.2	470.5	531.3					68
1707	273.4	273.4	632.8	879.1	942.1	1,063.9	X	X	X	X	36
					.3	.3					25

[1] These data represent the average daily supply that would be expected in 50, 80, and 95 percent of the years.

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources.* op. cit.

Table 101. *Water demand-supply balances in the United States, by aggregated subarea, 1975, with projections to 2020—continued*

(*Million gallons a day*)

Aggregated subarea	Water supplies[1]		Consumptive use projections (medium level)				Consumptive use equals or exceeds 95 percent supply				Percent of area of forest and range land
	Mean	95%	1975	1985	2000	2020	1975	1985	2000	2020	
California-South Pacific											
1801	27,910.9	12,980.0	2,157.8	2,395.0	2,480.3	2,800.9					80
1802	18,551.0	9,114.2	5,207.1	4,368.2	4,027.7	4,548.3					74
1803	23,936.4	12,689.7	15,161.2	14,313.2	13,170.8	14,873.3	X	X	X	X	53
1804	3,109.7	588.9	946.3	930.6	1,090.8	1,231.8	X	X	X	X	57
1805	1,376.2	51.2	1,066.4	982.1	934.8	1,055.6	X	X	X	X	68
1806	–876.1	–1,270.4	6,116.6	5,461.7	5,413.8	6,113.6	X	X	X	X	23
1807	202.5	202.5	779.0	528.3	525.9	593.9	X	X	X	X	34
Alaska											
1901	904,942.9	704,571.3	79.2	122.7	183.2	206.9					33
Hawaii											
2001	3,423.00	2,194.9	12.2	20.1	38.3	43.2					43
2002	1,153.3	403.5	186.6	188.1	200.7	226.6					59
2003	84.0	–142.2	143.2	148.2	163.9	185.1	X	X	X	X	67
2004	1,606.7	895.7	122.3	114.3	106.6	120.4					64
Caribbean											
2101	4,870.0	2,026.0	410.1	397.1	235.5	265.9					21
2102	.3	.3	.3	.3	.3	.3					25

[1] These data represent the average daily supply that would be expected in 50, 80, and 95 percent of the years.

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*. op. cit.

exceed the 95 percent supply. The Arkansas-White-Red Water Resource Region will have shortages in four of its seven aggregated subareas: Upper Arkansas (1102), Cimarron-Arkansas to Keystone (1103), Canadian (1105), and Red-Washita (1106). The major impact of a water shortage in all of these areas would be a reduced irrigation water supply. Although declining significantly, irrigation will account for 75 percent of consumptive water use in these areas in 2000.

Also in the South, four of the five aggregated subareas in the Texas Gulf Region are expected to experience water shortages: Trinity (1102), Brazos (1203), Colorado-Llano (1204), and Guadalupe-San Antonio-Nueces-Frio (1205). In much of the High Plains, irrigation is currently supported by ground water mining. In these areas, the water shortage in future years may be more severe than indicated by the data in table 101. Again, the major impact will be on irrigation since that is the lower value and high volume user in all areas. Manufacturing is also an important user in the Trinity. More than 70 percent of 1204 and 1205 is in forest and range land.

Moving westward, there are many more areas where water shortages are likely to occur. Water supply in the entire Rio Grande Water Resource Region, including five aggregated subareas, is expected to be short of demands. The major impact of these shortages will also be on irrigation water demands which will account for approximately 95 percent of total consumptive use in 2000. Forest and range lands make up 67 to 93 percent of these aggregated subareas.

Water demands in the Gila-Pedro Salt Basin (1503) of the Lower Colorado Region and the entire Great Basin (1601–1604) are expected to exceed the 95 percent level of supply in all projected years. Irrigation is by far the greatest consumptive user of water.

In the far west (Columbia-North Pacific and California-South Pacific Regions) five aggregated subareas are expected to experience water quantity problems. These include: the Upper and Middle Snake (1703), the Oregon Closed Basin (1707), Central Coastal (1805), South Lahanton (1807), South Coastal-Colorado Desert (1806), and Honolulu (2003).

Other aggregated subareas where projections do not exceed the 95 percent supplies, but are close enough to warrant specific mention, include: Niobrara-Loup-Elkhorn (1008), Green-Yampa-White (1401), Gunnison-Colorado to Delores (1402), Little Colorado (1501), Colorado below Lake Powell (1502).

In all of these areas where water shortages are expected, except in the Great Lakes Region, irrigation by far is the major consumptive water use. Water values for irrigation are among the lowest of all withdrawal or consumptive uses. As water becomes scarce, the decline in its use will ultimately occur in those of lowest value. Thus, it is evident that the water shortages enumerated will likely have the greatest impact on irrigation.

Water Quality

Water is not a uniform product. The fact that large quantities are available in relation to the amount required to meet the water demands in an area does not necessarily mean that the water related problems are insignificant or nonexistent. Quality determines the usability of water.

Water quality is impaired primarily by the use of a watercourse as a carrier of wastes. These wastes may contain pathogenic organisms harmful to human health. Salts, acids, phenols, alkalies, and other chemicals degrade water and restrict its uses. Dissolved and suspended materials affect the color and turbidity of water and can reduce the carrying capacity of stream channels. Heat added from industrial cooling may affect aquatic habitat and reduce the capacity to purify organic materials. Radioactive material in water could pose a threat to all forms of life.

Water quality in many areas is also lowered as a result of material eroding from the watershed. Although this material is mainly soil, it also includes other unwanted materials such as chemicals, minerals, and organic matter.

Information is not available to adequately analyze water quality on a Nationwide basis. However, a substantial body of data on quality has been collected by the Environmental Protection Agency. This information includes: (1) Estimates of the proportion of streams that have been classified as "water-quality-limited,"[8] and (2) a summary of the Nation's water quality situation.[9]

Streams classified as water-quality-limited.—Under the requirements of Federal Water Pollution Control Act Amendments of 1972 (PL 92–500), each State classifies stream segments into two categories: (1) Effluent-limited or (2) water-quality-limited.

A segment of stream is classified as effluent-limited if the water quality goals of the Act are expected to be achieved by 1977. In water-quality-limited segments, more stringent effluent limitations or nonpoint source controls are needed to meet the goals of the Act. The goals of the Act are likely to be achieved later than 1977 in these segments.

Estimates of the proportion of stream miles that are classified as water-quality-limited in each aggregated subarea are presented in table 102. Only one of the aggregated subareas in the United States has more than 70 percent of its streams classified as water-quality-limited. This is the Canadian River (1105) in New Mexico, Texas, and Oklahoma where much of the water is unsuitable for municipal or irrigation use because of pollution from oilfield brines and drainages over salt beds. The Canadian also has one of the heaviest sediment loads of any stream in the Nation.

Six of the Nation's aggregated subareas have 60 to 70 percent of their streams classified as water-quality-limited. These are Licking and Kentucky, Louisville-Salt, Evansville-Green (505); Illinois River (704); the Mississippi to Saint Francis (801); Verdigris-Neosho Lower Arkansas (1104); Red-Washita (1106), and the Puget Sound (1706). Heavy sediment loads are of concern in all of these areas. In addition, acid water from coal stripping is a major problem in area 505. Disposal from waste treatment systems and thermal pollution from power cooling is a problem in areas 704 and 801. Natural mineralization and municipal and industrial effluents are major pollutants in areas 1104 and 1106.

Four aggregated subareas have 50 to 60 percent of their streams classified as water-quality-limited. These include aggregated subareas Delaware River (203), Mississippi-Yazoo-Quachita-Tensas-Big Black (802), Lower Red River (1107), and Bear-Great Salt Lake Basin (1601). Serious municipal and industrial waste pollution problems exist in sections of the Delaware River and some of its tributaries draining urban and industrial zones. A further problem is caused by saline water intrusion during drought conditions in the estuary near Philadelphia. Acid mine drainage degrades parts of the Schuylkill and Lehigh Rivers.

Oilwell brine, muncipal and industrial effluents, natural acidity, and sedimentation are major pollution problems in area 802. The Red River (1102) is so named because of the concentration of suspended sediment, but natural mineralization, as well as municipal and industrial wastes, also affect its water quality. Salt concentrations and municipal effluents are causing water quality problems for the downstream areas of the Bear-Great Salt Lake Basin. This is also a basin where water quantity is expected to be in short supply.

The remaining aggregated subareas are estimated to have less than 50 percent of their streams classified as water-quality-limited. These will not be discussed further in this section, although table 102 contains estimates for each area.

[8] *The 1975 assessment of water and related land resources*, op. cit.

[9] *National water quality inventory*. Vol. I and II, op. cit.

Table 102

Estimates of the proportion of streams that are classified as water-quality-limited[1] in the United States, by region and aggregated subarea, 1975

Region and aggregated subarea	Percent
New England	
101	0 – 5
102	5 – 9.9
103	20 – 29.9
104	10 – 29.9
105	10 – 19.9
106	0 – 5
Middle Atlantic	
201	5 – 9.9
202	40 – 49.9
203	50 – 59.9
204	5 – 9.9
205	20 – 29.9
206	5 – 9.9
South Atlantic-Gulf	
301	30 – 39.9
302	20 – 29.9
303	0 – 5
304	30 – 39.9
305	40 – 49.9
306	20 – 29.9
307	10 – 19.9
308	10 – 19.9
309	20 – 29.9
Great Lakes	
401	0 – 5
402	0 – 5
403	40 – 49.9
404	0 – 5
405	0 – 5
406	20 – 29.9
407	30 – 39.9
408	30 – 39.9
Ohio	
501	5 – 9.9
502	30 – 39.9
503	20 – 29.9
504	10 – 19.9
505	60 – 69.9
506	30 – 39.9
507	10 – 19.9
Tennessee	
601	5 – 9.9
602	0 – 5
Upper Mississippi	
701	0 – 5
702	0 – 5
703	20 – 29.9
704	60 – 69.9
705	40 – 49.9
Lower Mississippi	
801	60 – 69.9
802	50 – 59.9
803	5 – 9
Souris-Red-Rainy	
901	0 – 5
Missouri	
1001	0 – 5
1002	0 – 5
1003	0 – 5
1004	0 – 5
1005	0 – 5
1006	5 – 9
1007	5 – 9
1008	0 – 5
1009	0 – 5
1010	0 – 5
1011	0 – 5
Arkansas-White-Red	
1101	40 – 49.9
1102	0 – 5
1103	20 – 29.9
1104	60 – 69.9
1105	70 – 79.9
1106	60 – 69.9
1107	50 – 59.9
Texas-Gulf	
1201	0 – 5
1202	5 – 9
1203	0 – 5
1204	0 – 5
1205	10 – 19.9
Rio Grande	
1301	0 – 5
1302	5 – 9
1303	5 – 9
1304	0 – 5
1305	10 – 19.9
Upper Colorado	
1401	0 – 5
1402	0 – 5
1403	0 – 5
Lower Colorado	
1501	0 – 5
1502	0 – 5
1503	0 – 5
Great Basin	
1601	50 – 59.9
1602	0 – 5
1603	0 – 5
1604	0 – 5
Columbia-North Pacific	
1701	5 – 9
1702	30 – 39.9
1703	10 – 19.9
1704	10 – 19.9
1705	40 – 49.9
1706	60 – 69.9
1707	0 – 5
California-South Pacific	
1801	0 – 5
1802	0 – 5
1803	0 – 5
1804	4 – 9
1805	0 – 5
1806	0 – 5
1807	0 – 5
Alaska	
1901	0 – 5
Hawaii	
2001	0 – 5
2002	0 – 5
2003	0 – 5
2004	0 – 5
Caribbean	
2101	5 – 9
2102	0 – 5

[1] Water-quality-limited—designated segments of streams where the goals of the Federal Water Pollution Control Act Amendments of 1972 (PL 92–500) will not likely be achieved prior to 1977.

Note: Data are preliminary and subject to revision.

Source: *The 1975 assessment of water and related land resources*, op. cit.

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In some river basins erosion resulting from poor land management practices creates water pollution, increases flooding potential, and lowers resource productivity. The productivity of this land can be restored only by a large investment and considerable time.

Water quality on major waterways.—In addition to the information on water-quality-limited stream segments, the Environmental Protection Agency has published an initial summary which ranks 22 major waterways in terms of relative water quality. The rankings are based on relative measure of instream water quality which results from point sources, nonpoint sources, and natural sources. These rankings are shown in the tabulation below.

The Environmental Protection Agency has also evaluated, in greater detail, water quality problems on eight of the 22 major rivers: the Mississippi, Missouri, Ohio, Tennessee, Detroit, Columbia-Snake, and the Willamette Rivers for which more pollution data are available.

The most significant types of pollution in the Mississippi River were undesirable bacteria (largely around urban centers) and elevated levels of phenols, which cause taste and odor problems in drinking water and fish flesh. Commercial fishing is prohibited in several long segments of the River.

Ammonia and nitrate levels were elevated in the upper river below Minneapolis-St. Paul, Minnesota. Turbidity and solids were high downstream from the confluence with the Missouri River. Although no algae growths were reported, phosphorus and nitrogen

Upper Third	*Middle Third*	*Lower Third*
Upper Missouri River	Rio Grande River	Hudson River
Columbia River	Alabama-Coosa River	Delaware River
Lower Tennessee River	Upper Ohio River	Middle Mississippi River
Snake River	Susquehanna River	Lower Arkansas River
Willamette River	Upper Red River	Lower Ohio River
Boston Harbor	Lower Colorado River	Lower Mississippi River
Upper Mississippi River	Potomac River	Middle Ohio River
Yukon River	Detroit Area Tributaries	Lower Missouri River
Chicago Area-Lake Michigan	Sacramento River	Chicago Area Tributaries
Upper Tennessee River	Lower Red River	Mississippi near Minneapolis
Detroit Area Rivers	Brazos River	Middle Missouri River
	Upper Colorado River	

were present in quantities sufficient to support algae growth, and levels were generally getting worse. The only noticeable salinity and acidity problems occurred below the inflows of the major tributaries. Dissolved oxygen levels were satisfactory throughout the river, except for occasionally low levels below Minneapolis-St. Paul. Fecal coliform counts were high throughout the Mississippi River, with peaks below urban centers, especially Minneapolis-St. Paul. These counts exceed the levels desirable for primary contact recreation and drinking water supply intakes.

The most significant types of pollution in the Missouri River were suspended sediment and organic pollutants near major cities. Special studies confirmed the presence of undesirable bacteria and viruses and tainting of fish flesh downstream of several large cities. These biological problems, apparently arising from point sources in metropolitan areas, are masked on about 9 to 16 percent of the days by pollutants associated with runoff following heavy rains.

The middle and lower segments of the Missouri experience some of the heaviest erosion in the United States. After rainfalls, pollutants washed from farms and cities are carried with the soil adding organic matter, nutrients, bacteria, and salts to the water. No algae growths were reported, although phosphorus and nitrogen levels were high enough to support such growths. At times, dissolved oxygen fell below the level recommended for fish, due in part to heavy animal feedlot runoff from Kansas, Nebraska, and Iowa. Fecal coliform levels were in excess of water quality standards for swimming and drinking downstream from urban areas in both wet and dry periods. Dissolved salts, particularly sulfates, reached and often exceeded national guidelines for water supply intakes in the middle and lower Missouri. Increased irrigation and coal development may aggravate this problem.

On the Ohio River, low alkalinity from mine drainage located on tributaries and high fecal coliform levels downstream from municipal sewage treatment plants caused problems. Also increasing high iron and manganese concentrations were noted. In addition, biological studies showed the presence of toxic materials downstream from Pittsburg. From 1963–67 to 1968–72, the most noticeable trends in Ohio River pollution were increased concentrations of iron, manganese, DDT, and chlordane.

Special studies showed industrial oil, scum, foam, phenols, and other chemicals affecting areas near Pittsburg, Huntington, Marietta, and Parkersburg. Downstream the river is showing recovery, and some improvements have been noted since 1970. High levels of suspended solids occurred in the lower Ohio, primarily during high flows. Nitrates and phosphates were high enough to support undesirable algae growths, but other factors—such as turbidity—were inhibiting growth. The river violated acidity standards at 11 of 40 stations for at least 15 percent of the observations, due primarily to acid mine drainage in upstream tributaries, as well as industrial acid discharges. Pittsburgh and Cincinnati municipal discharges were known to be causing low dissolved oxygen at times, but the condition was not widespread. Field studies indicate that if industries and municipalities adhere to effluent limitations, the Ohio could meet standards for fish, and in some areas for swimming, by 1977. However, nutrients and sediment runoff may continue to be a problem.

The Environmental Protection Agency study showed that water in the Tennessee River was of good quality except for undesirable levels of bacteria below the urban areas. Dissolved oxygen levels were very high throughout the river except below Knoxville and Watts Bar Lock and Dam. Releases from known major sources of mercury have been reduced to acceptable levels, and a program of sampling bottom sediments and fish flesh is continuing. In terms of the broad chemical indicators of acidity and salinity, the Tennessee was in good condition.

The focal point for water quality in southeastern Michigan is the Detroit area and the many waste dischargers along the lower two-thirds of the 30-mile long Detroit River. Water quality measures, such as suspended solids, phenols, pH, chlorides, ammonia, cyanides, and iron, have improved noticeably over the past 10 years. Phosphorus loadings to Lake Erie were reduced significantly in 1971–73 over the preceding 10 years. Nitrates, dissolved oxygen, and coliforms, which tend to be associated with municipal discharges, have changed little. Tributaries in the area have generally shown improved conditions, the most notable being the Clinton and Rouge Rivers. Three tributaries—Belle, Pine, and Black Rivers—showed good quality, with the Raisan River having mixed conditions.

The general physical quality of the Detroit River was good. Temperatures were naturally cool, but did show a 1 to 4C. increase along the shore of the lower river, reflecting localized effects of heat discharges. Salinity, alkalinity, and acidity were minimal, and water quality was improving despite large acid and chloride discharges. Coliform numbers in the lower Detroit River and some tributaries have generally remained unchanged over the past 10 years. Data indicate there is a problem of combined sewer overflows primarily during rainy periods, with coliforms being high enough to endanger water contact recreation.

The Columbia River has responded favorably to pollution abatement efforts, yet certain problems re-

main. The supersaturation of gases in the water that is induced during spillway releases from 13 dams along the river is toxic to fish. Radioactivity levels have increased significantly below the Hanford Works, but beta radiation counts have been within drinking water standards since 1964. Slime growths were a problem in the lower river. Limited data indicated that total coliform levels were very low and indicate no threat to recreation contact or drinking water use.

Water quality of the Willamette River has improved dramatically. Dissolved oxygen no longer violates standards, as it frequently did during periods of low flow in the past. The total coliform standard continues to be exceeded more often than met, especially at high streamflows, but 1971–72 counts were distinctly lower than 1966–67 counts. Sulfite waste liquor—toxic to fish—from pulp and paper industries was still high in the lower 80 miles of the river, even after a twofold improvement in 1971–72 over 1966–67. Violations of the pH (acidity) criteria have decreased noticeably.

During high streamflows, the river is very turbid, carrying large amounts of sediment. Man's activities (logging, construction, agriculture) are primarily responsible. Temperature criteria were exceeded repeatedly in the summer. The waters of the Willamette were low in dissolved mineral salts and dissolved oxygen levels were adequate.

The Snake River has experienced frequent instances of pollution which include nuisance algae blooms in the upper river and dissolved oxygen deficiencies at widely separated points, especially in reservoirs. Like the Columbia River, the lower Snake has dissolved gas supersaturation below hydropower dams. Turbidity was objectionable in the upper and middle river sections, and dissolved solids from irrigation return flows, erosion, and natural runoff were high in the middle section. Agricultural activity has introduced pesticides in the upper river. Bacteria from municipal and industrial discharges, as well as from runoff, exceeds legal criteria for most of the river.

Rich phosphate deposits in the basin contribute significant amounts of phosphate during rain storms, and irrigation return waters are rich in nitrogen and phosphorus. Municipal and industrial discharges also contribute these nutrients. Widespread irrigation activities in the Snake Basin increase the dissolved solids concentrations in the river.

Major quality issues as identified by the States.—As part of the Environmental Protection Agency Study, each State was asked to identify its major water quality problems. Major sources of pollution identified are shown in table 103. This summary may not be representative of the complete water quality problems since the reporting detail was not necessarily consistent between States. Both point and nonpoint sources were identified.

The point sources of pollution can be delineated into three general categories: (1) Municipal waste, (2) industrial waste, and (3) other. Municipal waste was listed by 43 States as a major pollution problem. Of the States that did not list municipal waste as a pollution problem, only California has a major metropolitan center(s).

Industrial waste problems were divided into pulp, paper, and lumbering; food processing; thermal; and "unclassified."[10] The unclassified category is the largest, with 22 States listing industrial pollution, but not always listing the specific industry involved. The food processing industry was listed by seven States as a major pollution problem. Thermal pollution was specifically identified by four States. Pulp, paper, and logging activities were also identified by four States as major contributors to pollution.

The "other" category under point sources includes water problems caused by feedlots, recreation, and vessel pollution. Drainage from livestock feedlots was listed as a problem by eight States, all in the West-Central United States. Recreation was a problem identified by five States, and pollution from vessels was listed by three.

Nonpoint sources of pollution have been categorized into problems caused by agricultural runoff, agricultural irrigation, mining, silvicultural activities, and contruction. Agricultural runoff was specified by 19 States as being a nonpoint source of pollution. A somewhat related cause, irrigation return flows, was identified by 12 States as being a problem.

Mining—mostly acid mine drainage—was cited by 15 States as a nonpoint problem. Construction activities were listed by nine States, and silvicultural activities by five.

Opportunities for Extending and Increasing Supplies

As can be seen from some of the earlier comparisons, there are many areas where water supply (amount of water available for the intended uses) will need to be augmented if projected demands are to be met. This can be done in part by making more efficient use of existing supplies and increasing usable water supplies in a given area.

Developing better methods of pricing can be a means to more efficient use. The limited supply of usable water should be allocated among the uses that are the most productive. The pricing mecha-

[10] Many of the States listed industrial pollution, but provided no further explanation of specific cause. Causes that do not fit into the remaining three categories are also lumped in "unclassified."

nism can be an effective way to do this. Most current pricing schemes are not based on incremental costs. Some charge a flat fee regardless of the amounts used. Others offer lower prices for increasing use. Charging a unit price that represents the marginal cost of production will shift the scarce water resource to its most productive use.

The National Water Commission concluded that systems of pricing and user charges that recover the full cost of water services directly from users will conserve water supplies, discourage premature investment in water development projects, reduce financial burdens now borne by nonusers and, most importantly, make more efficient use of scarce resources.[11]

The greatest potential for increasing efficiency is in the irrigated areas of the West. Irrigation accounts for about 82 percent of total water consumptive use, most of which occurs in the arid and semiarid West.

Also, it should be possible to reduce water transmission losses from irrigation considerably. Both seepage and evapotranspiration losses are quite high in some areas. Possible solutions include lining channels and laterals, conversion from surface flooding to trickle irrigation, use of underground storage in years of high runoff, and phreatophyte management. The latter may have environmental effects that must also be considered.

In urban areas, water use can be made more efficient by controlling leaks in transmission systems, installing water meters and charging according to use, by the design of plumbing fixtures and appliances that use less water, public information programs, implementation of water saving technology by recycling municipal and industrial wastewater, and water pollution control.

Water use in manufacturing could be made more efficient through more recycling procedures. Recent technological advances have permitted the steel industry to reduce water requirements by 90 percent in water short areas. Perhaps the greatest saving can be achieved by reuse of cooling water, which accounts for more than 65 percent of all industrial withdrawals.

Among the opportunities for increasing usable water supplies in a given area are: interbasin transfers, desalting, precipitation modification, and watershed management.

The physical transfer of water from one watershed to another has been a common means of augmenting supply. For example, part of Denver's water supply comes from the Colorado River basin which is across the Continental Divide. Los Angeles imports water from the Great Basin, the Colorado Basin, and the Sacramento Basin. Each project must be evaluated on its individual merits. To properly evaluate interbasin transfers, it is necessary to examine the legal framework, the ways of protecting the exporting basin, the economics of the project, the social and environmental implications, and the institutional arrangements necessary to implement the project.

Because of increasing water demands and relatively fixed natural supplies of water, it is likely that desalting will become significant in the future. This applies especially to the use of smaller desalting plants, less than 10 million gallons per day capacity, in areas where other supplies are costly, where there are natural supplies of brackish water, where existing supplies need to be upgraded, or where point sources of dissolved solids can be treated. Desalting costs have been reduced from approximately $7.00 per 1,000 gallons in 1952 to approximately $1.00 per 1,000 gallons for sea water conversion, and $.50 for brackish water plants at the present time. The projects that are energy intensive will be less attractive as energy costs increase.[12]

The prospects for successful modification of rainfall and snowfall patterns to increase yields have begun to look promising. Cost estimates ranging from $1.00 to $2.30 per acre foot of additional runoff have been cited. However, these represent only the direct capital and operation costs, and do not include any indirect economic, environmental, or ecological related costs. Uncertainties about both direct and indirect effects, as well as many legal and institutional implications, have caused much controversy about precipitation modification. The National Water Commission concluded that precipitation modification has potential in certain limited areas, but available information is insufficient at this time to develop a comprehensive national policy.

Forest and range lands are important sources of the Nation's water supply. Commercial and noncommercial forests occupy about one-third of the total precipitation of the Nation. Forest lands receive an average of 42 inches compared to 24 inches annually on other lands. Forest lands yield 17 inches of annual runoff compared to 4 inches from other lands.[13]

Watershed management on forest and range land can augment water supplies by enhancing the natural recharge of ground water, by slowing the rate of overland flow, and improving the infiltration rate through proper vegetative and cultural practices.

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[11] National Water Commission. Water policies for the future. Final report to the President and to Congress. U.S. Government Printing Office, Washington, D.C. 259 p. 1973.

[12] Water policies for the future. Final report to the President and Congress, op. cit.

[13] Sopper, William E. Watershed management. Prepared for the National Water Commission. NTIS, Springfield, Va., Accession No. PB206370. p. 2. 1971.

Table 103. *Major water pollution sources in the United States, by State, 1972*

State	Point sources								Nonpoint sources				
		Industrial waste				Other							
	Municipal wastes	Pulp, paper, and lumbering	Food processing	Thermal	Unclassified[1]	Recreation	Livestock feedlots	Vessels	Agriculture runoff	Irrigation return flow	Mining	Silviculture	Construction
Alabama	X												
Alaska	X	X	X										
Arizona										X			
Arkansas	X					X			X	X	X	X	
California									X	X	X	X	X
Colorado	X				X	X	X			X	X		
Connecticut	X												
Delaware	X		X		X								
Florida	X			X	X				X		X		X
Georgia	X												
Hawaii	X							X		X			
Idaho					X					X	X	X	
Illinois	X			X	X				X		X		
Indiana	X		X		X						X		
Iowa	X						X		X				
Kansas	X						X			X			
Kentucky*													
Louisiana	X				X								
Maine													
Maryland	X		X					X	X		X		X
Massachusetts	X				X								
Michigan	X				X								

Minnesota	X				X				X				X
Mississippi	X				X								
Missouri	X		X	X		X	X		X		X		X
Montana											X		
Nebraska	X				X		X		X	X			
Nevada	X									X	X		
New Hampshire	X	X	X		X								
New Jersey	X				X								
New Mexico	X								X	X			
New York	X												
North Carolina	X								X				
North Dakota							X						
Ohio	X			X	X				X				X
Oklahoma	X				X		X						X
Oregon	X	X		X		X				X		X	
Pennsylvania	X										X		
Rhode Island	X				X								
South Carolina	X				X				X				
Tennessee	X				X								
Texas	X						X		X	X	X		X
Utah	X					X				X			
Vermont	X				X								
Virginia	X	X	X					X			X		X
Washington	X								X	X		X	
West Virginia	X				X						X		
Wisconsin	X				X								
Wyoming													

*No assessment available.

[1]Specific cause not identified other than "industrial pollution," or causes do not fit into other three categories.

Source: United States Environmental Protection Agency. National water quality inventory, Vol. 1. U.S. Government Printing Office, Washington, D.C. p. 279–305. 1974.

Courtesy Soil Conservation Service

Watershed management practices, such as seeding and terracing, can improve resource productivity and water quality on forest and range lands. These practices are generally most effective on lands that have been mismanaged in the past.

Watershed protection and management is needed not only to insure the optimum combination of water quantity and water quality at a given location, but also to protect and enhance land resources such as soil and vegetation. For some situations, increasing water supply through land management might be the best way to proceed. In other cases, these techniques involve adverse side effects which should not be overlooked.

Vegetation has an effect upon water supply in a number of ways. It intercepts rain and snowfall which are evaporated from the surface of leaves and needles. It draws moisture from the soil and releases it into the atmosphere by transpiration. On the other hand, through the beneficial effects of its roots, leaves, and other residue, it may improve ground water supply by facilitating the infiltration of precipitation into the soil.

Water supplies can be increased in many areas by thinning the vegetative cover and in some areas through a conversion of the vegetative type. For example, research has shown that on certain soils available water can be substantially increased by converting chaparral to a grass cover. Thinning ponderosa pine stands also increases streamflow on certain sites.

Winter snowpacks can also be managed to increase the usable water supply. Openings in the forest tend to trap snow, and wind currents redistribute it into the forest where shade prolongs the snowmelt. These openings can be created by forest management. However, many constraints limit the feasibility of snowpack management to specific high value areas. To have a significant impact on the flows of a large watershed (21,000 square miles), a large acreage of forest land would need to be intensively managed to complex patterns. The natural hazards in the landscape—as well as esthetic consideration and operating costs—make such an operation difficult to plan and execute.

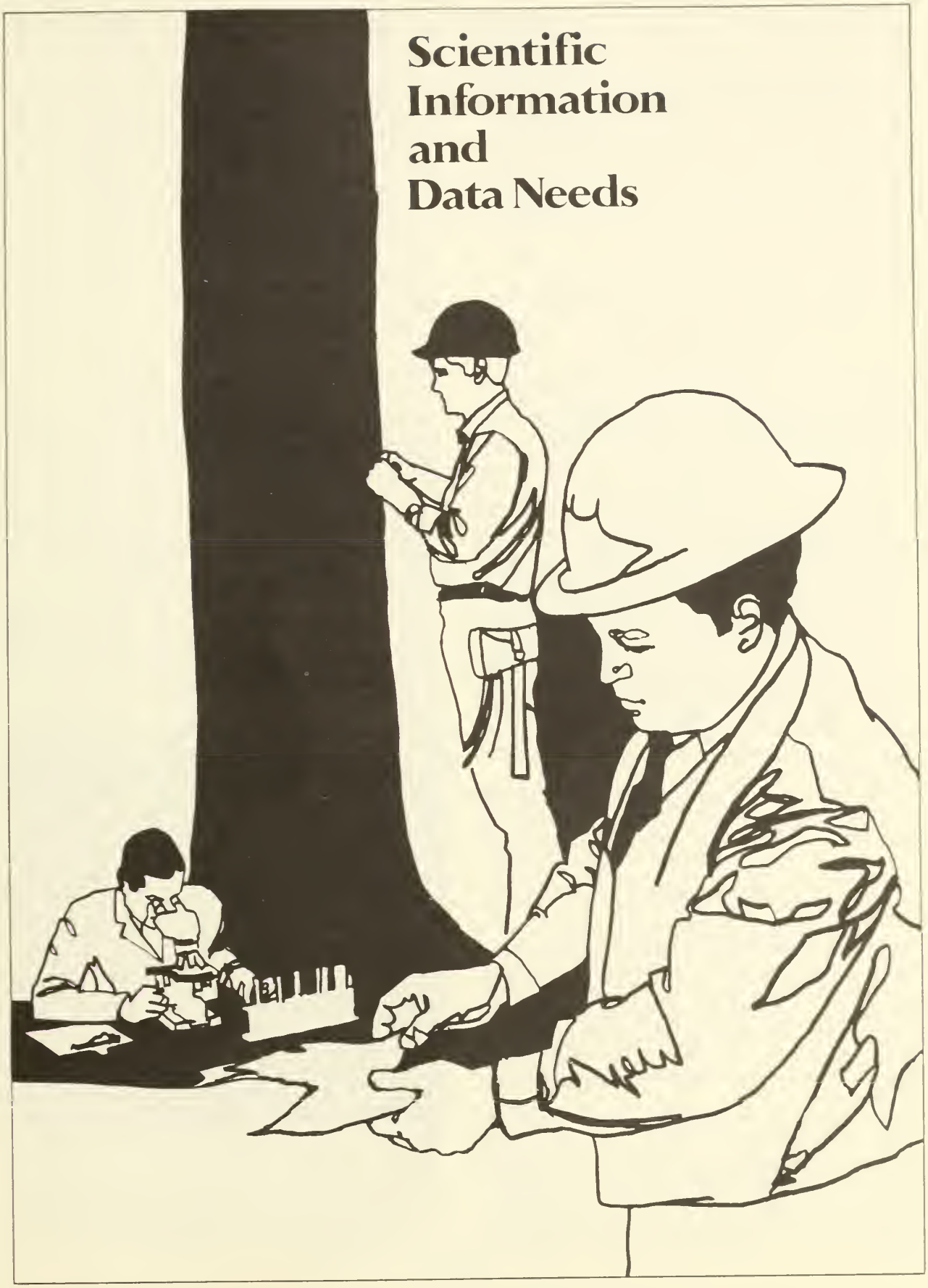
Available water resources in the western Regions could be increased through removal of phreatophytic plants. Phreatophytes occupy about 16 million acres with a water consumption rate of about 22 billion gallons a day. It may be possible to reduce this consumption somewhat through a phreatophyte control program. Such a program may result in increased sedimentation and loss of preferred wildlife habitat if not managed properly.

Erosion and sedimentation can be significantly reduced and supplies of usable water increased with

improved land management. Conservation measures applied to watershed lands could reduce sediment yields significantly; for example, sediment yield may be reduced by as much as 90 percent by changing the poorly suited cropland to continuous vegetation. Numerous experiments conducted by the Forest Service confirm that forest soil erosion and water quality degradation are products of poor forest management activities, grazing, and wildfire. Roads can be a major source of erosion and sediment unless they are located on stable slopes, away from streams, with appropriate drainage structures.

Thus, management of land resources can, in some cases, result in increased water supplies (because of less evapotranspiration) and improve the usefulness of supplies (by delaying out runoff). Adverse impacts must be taken into consideration in order to provide the greatest benefits.

Scientific Information and Data Needs



Many kinds of scientific information and data are necessary for the development and guidance of forest and range land policies. Such information also provides a basis for judging the progress and results of management practices and programs and identifying opportunities for economic development of forest and range resources. The discussion is primarily concerned with the need for (1) inventories of forest, range, and inland water resources, (2) estimates of physical responses of forest, range, and inland waters to changes in management practices, (3) surveys of the use of forest and range products, and (4) research on the techniques of collecting data and information needed for management purposes.

Inventories of Forest and Range Resources

Inventories of forest, range, and inland water resources are basic to almost any decision concerning the management or use of these resources.

Timber

The importance of timber resource inventories was recognized in the McSweeney-McNary Forest Research Act of 1928. Section 9 of this Act authorized and directed the Secretary of Agriculture to make and keep current ". . . a comprehensive survey of the present and prospective requirements for timber and other forest products in the United States and its territories and possessions, and of timber supplies including a determination of ways and means to balance the timber budget of the United States." Appropriations were authorized to complete an initial survey of timber resources and to keep the survey current.

The Forest Survey was organized in the Forest Service in response to the McSweeney-McNary Act. Since then, initial inventories of the timber resources of all States and Territories have been completed and most of the important forested States have been reinventoried at least once. Following the intent of Congress, the Forest Survey has been primarily concerned with the collection of basic information on the area and condition of commercial timberlands. Data are gathered about timber ownership; the volume, quality, and location of standing timber; trends in timber growth and mortality; the amount and kind of timber cut for industrial and other products; and prospective trends in timber supplies.

While the Forest Survey is the primary source of data on the timber source, information is also collected by other public and private organizations such as the National Forest System, Bureau of Land Management, Bureau of Indian Affairs, State forestry organizations, and large private landowners. Where available and compatible, the data collected by these agencies are used in compiling Forest Survey reports.

In most forested areas, surveys are carried out on a State-by-State basis. As the surveys are completed, the results are published in various kinds of resource reports. Periodically, the State data are aggregated into regional and national summaries. In addition to the statistical data outlined above, these reports contain descriptive information on past and prospective trends in forest areas and in timber volume, growth, and removals. The national reports, and many State reports, also contain an analysis of the impacts of these trends on the current and future timber resource.

The information in the Forest Survey reports provides a basis for judging the progress and results of timber management programs. In addition, it provides a partial basis for identifying opportunities for investments in timber management programs and timber product manufacturing facilities. In conjunction with analyses of present and prospective demands for timber products, it also provides (1) a way of identifying future imbalances between demands and supplies, (2) an indication of prospective increases in prices and (3) the kinds and size of forestry programs needed to balance timber demands and supplies at some price goal.

Although the Forest Survey is a comprehensive source of statistically reliable timber resource data, there is a need to accelerate this work. The present survey cycle, or time between State surveys, averages 17 years. This is far too long to adequately monitor the changes taking place in the timber resource. In some forested States where there has been rapid industrial development, timber removals have changed by as much as 40 percent in a 10-year period. In other areas such as the Delta region of Arkansas, Louisiana, and Mississippi, forest land clearing has been averaging more than 300,000 acres a year. Obviously, in areas where such fast changes are taking place, inventory cycles of more than 5 years are of limited usefulness in guiding industrial development and resource planning and management.

The survey should also be intensified to provide more precise local resource data. Present Forest Survey sampling standards are designed to achieve acceptable sampling errors for relatively large timber volumes (1 billion cubic feet of timber) or large areas of commercial timberland (1 million acres). This limits the usefulness of the data for local governments, planning agencies, and forest industries needing statistically reliable information for relatively small geographic areas such as a county. Intensification of the survey to provide this information would greatly facilitate local land use planning,

management of forest lands including those in small private ownerships, and more efficient use of the timber resource.

Finally, there is a need to expand the Forest Survey to include other forest and range land resources. In the past, the Forest Survey has been primarily concerned with collecting data on timber resources. The Forest and Range Land Renewable Resources Planning Act of 1974 through amendment of Section 9 of the McSweeney-McNary Forest Research Act authorizes and directs the Secretary of Agriculture to make and keep current a comprehensive survey and analysis of the present and prospective conditions of the renewable resources of the forest and range lands of the United States.

Land Classification

A land classification system which can be used by all concerned with the management and use of forest, range, and inland waters is a basic prerequisite to the resource data collection required by the Resources Planning Act. The development of a comprehensive classification system is still in the formative stages. Although several systems have been proposed, they all lack either sufficient scope and development for national application or they fail to meet some of the fundamental classification principles. Vegetation and soil classification systems are fairly well developed but very little work has been done on aquatic systems and there are no operational classification systems for lakes, streams, and marshes.

The Forest Survey conducted by the Forest Service is a comprehensive source of statistically reliable data on timber resources. The present average time between surveys of about 17 years is far too long to adequately monitor the rapid changes in timber resources in many States.

Recent research on classification indicates that most existing classification approaches and previous work can be utilized with minor modification. This research needs to be accelerated so that a comprehensive framework can be completed and tested and cost-effective operational classification systems identified for the major ecosystem divisions of the United States.

Range

Prior to the passage of The Resources Planning Act, there was no legislative mandate requiring a continuing inventory of the Nation's range resources. In the past, a substantial amount of information had been collected by various public and private agencies to meet the specific needs of management organizations or the requirements of special studies. As a result, it is of limited usefulness in formulating and guiding range management policies and programs and appraising economic opportunities for the use of the range resource.

It is clear that a systematic survey of range resources must be organized with national standards and specifications on the kinds of data to be collected. The primary objective should be the collection of basic statistical data on the areas and condition of range by class of ownership; the kinds, volume, quality, and location of forage; amounts and kinds of grazing by domestic livestock and wildlife; and major factors affecting suitability for grazing such as topography, climate, and the availability of water.

There is also a need to gather quantitative data on the impacts of different intensities of livestock grazing on the use of the land for other purposes such as outdoor recreation or the production of wildlife, timber, and/or water.

Wildlife and Fish

The Federal government has the responsibility for the protection and administration of migratory waterfowl. The States have primary legal responsibility for the protection and administration of fish in inland waters and resident wildlife species. However, the Fish and Wildlife Act of 1956 included provision for the Secretary of the Interior to conduct continuing investigations; prepare and disseminate information; and make periodic reports with respect to the availability, abundance, and biological requirements of the fish and wildlife resources.

Currently, the various State wildlife organizations and the U.S. Department of Interior conduct inventories of game populations and public hunting and fishing activities. Studies also are made to determine

landowner attitudes toward hunting, fishing, and other fish and wildlife uses involving public access to private lands.

Although considerable data are available on important game species, there is a need to expand inventory work to include all species. In recent years, there has been growing recognition of the importance of nongame species and increased efforts to inventory all species of wildlife, especially endangered or threatened species. Despite these efforts, inventory work on nongame species is still in the beginning stages. The collection, on a periodic basis, of data on population levels and trends will require a very substantial expansion of present work. In addition, there is a need to standardize the kinds of data collected and the timing of surveys. This would greatly increase the usefulness of the data collected for regional and national planning and management of species with large geographic ranges.

Effective management and preservation of terrestrial wildlife species is dependent on management of vegetation. Much information is currently available on the vegetation of forest and range lands. However, there is a need to collect in a systematic fashion data directly useful in wildlife management such as the production of browse, forage, and mast; understory vegetation; indicator species; and foliage diversification. Special attention should be given to collecting data on habitats of threatened and endangered species and on vegetation critical to winter survival.

Effective management of wildlife and fish also requires information on the impacts of various management practices; disturbances such as logging, fire, insect and disease attacks, and pollution on habitats and populations.

Water

Responsibility for inventorying the Nation's water resources has been assigned by the Congress to several Federal agencies. The Water Resources Planning Act of 1965 established the Water Resources Council. Among other functions, this Council was "to maintain a continuing study and prepare periodically an assessment of the adequacy of supplies of water necessary to meet the water requirements in each water resources region in the United States and of the national interest therein." Section 305(a) of the Federal Water Pollution Control Act Amendments of 1972 (PL 92–500) requires that the Federal agencies report to the Congress on water quality.

A number of other Federal, State, and local agencies are collecting data on the Nation's water resources. The principal Federal water-data collection agencies are the Geological Survey, National Oceanic and Atmospheric Administration, the Environmental Protection Agency, and the Soil Conservation Service. A number of current statistical reports and studies of these agencies provide considerable information on the national water resource situation.

In the past, most of the water data collected has been on rainfall, surface water, and ground water charge and discharge. This was needed to provide sound hydrologic information for water planning and development. Recently the data collection activity has broadened to include the monitoring of the biological and ecological aspects of water.

The National Water Resources Council has recognized deficiencies in the current water-data base. Additional information is needed, for example on environment of surface water landscapes, costs and use effects of various land use activities on water supply and quality, nonpoint sources of pollution, and the relationships between energy production and water use.

Outdoor Recreation

As the result of special studies and surveys of various public and private organizations, a substantial amount of information is available on the Nation's outdoor recreation resources. However, as with range and wildlife, most of this information was collected for specific studies or management needs and is of limited use in guiding recreation management on forest and range lands. The past work needs to be expanded into a systematic continuing survey with national standards and specifications on the kinds of data to be collected.

This survey should include an inventory of the forest and range land available and suitable for outdoor recreation. It should inventory existing outdoor recreation facilities by location, ownership, and type of facility. It should also identify those areas with characteristics which make them especially desirable for some type of outdoor recreation activity.

Unique Features of Forest and Range Lands

In recent decades, there has been growing interest in identifying and protecting the unique features of forest and range lands such as archeological or historical sites, habitats of rare or endangered species of plants and animals, and "unique islands" of undisturbed forest or range vegetation. While many of these features have been identified and protected, much remains to be done and it should be done soon. If not set aside in the near future, many of these features will be destroyed or damaged by the use of the land or water for other purposes. Thus, it is important to accelerate the work underway and protect these special places.

Other Inventory Needs

The inventory needs described above are not intended as a complete listing. They are based on current knowledge of the kinds of information required for efficient management of forest and range land and inland waters. Further study will lead to a better understanding of the objectives of inventories and the kinds of data that need to be collected. It seems clear that this study should be conducted before the present Forest Survey, now largely concerned with timber, is expanded to include other forest and range land resources. Such study, particularly for resources such as grazing, wildlife, and recreation where past inventories have been fragmented and limited, will undoubtedly lead to the modification of needs as currently perceived.

Physical Responses of Resource Systems to Changes in Management Practices

Determination of the size and kinds of management programs which will most effectively and efficiently supply forest, range, and inland water products requires information on physical responses to management activities. In general, the currently available response data is limited. Further quantification of responses to various practices as well as multiresource interactions is basic to improving the quality of management.

Considerable research has been done on responses of softwood stands to some management practices such as commercial thinning. Very little has been done on other practices such as precommercial thinning, site preparation, and fertilization.

Timber

At this time, when the economics of investing in timber management are becoming more favorable and management more widespread, there is a special need for data on timber growth and yield responses to common management practices.

Information on yields from fully stocked timber stands with trees "normally" distributed among diameter classes is available for most important timber types in the United States. There are some technical problems with these yield tables, such as inconsistency in the definition of "normality." The major problem, however, is that actively managed stands, either even-aged or all-aged, do not exhibit full-stocked natural stand characterisitics. The information available is not adequate for estimating the yield responses to management activity in these stands.

In addition, a large proportion of forest stands do not have a normal distribution of diameter classes. Recent but limited research indicates that intermediate treatments of these stands provides some of the highest financial returns available from timber practices. However, more complete information on growth and yield responses to management is required to determine the extent of the existing opportunities.

Considerable research has been conducted on stand responses to some management practices such as commercial thinning of even-aged conifers and cull removal in hardwoods. Relatively little has been done on other practices, such as precommercial thinning in conifer stands or the response of planted trees to site preparation. The response of loblolly pine, slash pine, and Douglas-fir to fertilizer has been analyzed, but similar analysis should be made for other species. Yield increases resulting from first generation genetically improved stock in young stands of slash and loblolly pine are fairly well documented on some sites and preliminary estimates are available for Douglas-fir but similar information is lacking for most other species.

Most of the existing yield data is applicable only to localized areas. Growth and yield response estimates should be developed from a broad enough data base to permit extrapolation of results to large geographic areas such as States and regions.

Development of better timber growth and yield response data is partially constrained by the time it takes timber stands to grow. Because of the need for such data for analysis of prospective timber supplies, timber investment programs, and allowable levels on National Forests, systematic effort should be made to put together the best information currently available.

In addition to the need for data on timber responses to management, there is a need for data on the effects of various practices on the production of

other products such as wildlife, forage, and water. The need for this kind of information will become increasingly important as more and more of the Nation's forest land is used for multiple purposes.

Range

There is a substantial amount of information on the responses of highly productive rangeland to common management practices such as seeding, fertilization, and brush clearing. However, more physical response data is required to determine whether current practices represent optimum management. There is also a need to collect data on responses to management practices which are not common such as type conversion, prescribed burning, and the use of alternative grazing systems. There is a further need to gather data on responses from management practices on the less productive forest-range ecosystems, like the true-fir-Douglas-fir of the Pacific Coast States and the chaparral and pinyon-juniper of the Southwest. These have not been studied.

Studies of responses to individual practices also need to be expanded to include the cumulative effects of combining individual practices into range management systems. The effect of grazing various rangeland ecosystems, and the impact of various management practices and grazing intensities on wildlife and other uses of rangeland, has received little study.

Wildlife and Fish

In some respects, management responses data are most limited for wildlife and fish. This is primarily due to the many complex factors such as animal mobility which make it difficult to gather quantitative data.

Research has provided information on population responses to a limited range of management activities for some species—chiefly big game, threatened and endangered species, and important sport and commercial fishes. However, it is not possible with existing information to determine the impact of land management activities on most wildlife and fish species. Information is especially limited on nongame species which are becoming of increasing importance and concern to large numbers of people.

Many factors, such as predator populations, the incidence of insects and diseases, and the health and productivity of local populations influence population responses. Studies of responses to management must include adequate consideration of such factors if they are to provide adequate guides for program administrators.

The social character of some species is also important; individuals will only live so close to others of the same or associated species despite food and cover adequacy. Until species interrelationships are better defined, it will be difficult to determine the impacts of habitat manipulation.

Water

There is a long history of records and research on water on the 140 experimental and 20 representative river basins in the country. Most of the analysis has centered on water yield, including the impact of vegetative manipulation. As a result, it is possible to reliably estimate water yield responses that would result from changes in management practices on small watersheds in most parts of the country. The accuracy attainable on large watersheds is of a much lower order of magnitude and there is a need to expand present work to correct this deficiency.

Suspended sediment is a major problem to downstream water users through impact upon municipal water supplies, stream channels, irrigation uses, and biological productivity. High turbidity also has an adverse recreational impact. Although considerable research has been done, the accuracy of predicting sediment yields resulting from various management activities is low, partly because sediment yield is highly variable.

There is another and prehaps more important need to identify and quantify the nature and extent of water pollution resulting from forestry and range management activities such as timber harvesting, site preparation, fertilization, controlled burning, and insecticides and herbicides; and the effects of these pollutants on aquatic ecosystems and habitats.

Multiresource Interactions

The demand for all products of forest and range lands has been growing rapidly. Projections contained in other parts of this study indicate continued rapid growth in the decades ahead. As demands grow, conflict among users will intensify as efforts to increase output of some products constrain or reduce the output of others. The resolution of these conflicts will depend in part on quantitative information on the interactions among product outputs resulting from management actions.

Some research on the joint production of several products from the same land areas has been conducted, the impact of timber harvest upon water yield being probably the best example. Some other resource interactions have also been studied such as the big game livestock grazing interaction in the West. However, most of the multiresource interactions have received very little study. As the competition for the use of forest and range lands increases, information on these interactions will be increasingly vital and the best hope of attaining efficient use of the land and water resources.

Surveys of Use of Forest and Range Land Products

In order to plan investments in public and private programs for the management of forest, range, and inland waters, as well as associated manufacturing and recreational facilities, information is needed on the use of forest and range products in the national economy. Present information collected by the U.S. Department of Agriculture on livestock grazing on forest-range land and by the U.S. Department of Commerce and other Federal and State agencies on water use seems adequate for most management and planning purposes. More information is needed, however, on timber products, wildlife, and outdoor recreation.

Timber products.—Information on the consumption of timber products in major end uses such as construction, manufacturing, and shipping; and minor uses such as mining and cooperage manufacture; has been collected periodically in response to the requirements of the McSweeney-McNary Forest Research Act of 1928. However, this work has lagged seriously in recent years. For instance, the last survey of timber products use in single family detached housing was for 1968. Wood use in manufacturing was last surveyed in 1965. Data on most other end uses is older or nonexistent. The old data that are available are of little value in guiding production and marketing strategies of the timber industries. They are also of limited usefulness in preparing projections of future timber demands, which along with supply projections, provide the basis for judging the kinds and sizes of forestry programs needed to bring about an improved timber situation.

Thus, at this time, there is some urgency in expanding and accelerating the ongoing survey work to obtain current data on timber products consumption in all important end uses. In view of the rapid changes in population, economic activity, technologies, and prices of substitute products and energy, it is also necessary to repeat the surveys at intervals short enough to insure that all significant changes in use can be identified, analyzed, and evaluated.

Wildlife.—There is a substantial amount of information available on game harvests and numbers of hunters and fishermen. For example, statistics on the yearly harvest of migratory waterfowl are prepared annually by the U.S. Department of Interior. Information on big game harvested on the National Forests and other Federal lands open to hunting are reported annually by the managing agencies. Various State wildlife agencies collect data on big game harvests on private lands, small game harvest, fish catches, and numbers of hunters and fishermen.

Although much information is collected, there are problems of comparability both in the kinds of data collected and the timing. As a result, it is difficult to summarize the data for analyses of regional or national problems. Development and implementation of standardized reporting of annual game harvests would greatly increase the usefulness of the data.

Outdoor recreation.—The Nation's forest and range lands provide the setting for varied leisure activities for millions of Americans. Camping, wilderness hiking, picnicking, nature study, and other forms of outdoor recreation have become increasingly important uses of forest and range lands. Yearly recreation use estimates are available for the National Forests and National Parks. At present, however, there are no comprehensive data that measure outdoor recreation use by major type of activity on all forest and range lands and the associated inland waters. There is also a related need for better information on demographic characteristics of outdoor recreation users and the relationships to various types of recreation activity.

Surveys of Cost of Management Practices

An essential part of resource management planning is the determination of priorities in allocating management investments. Basic to this process is the ranking of costs and returns (physical and financial) from alternative management practices. Frequently, renewable resources managers and planners are handicapped by the lack of relevant cost data for most management practices.

This is particularly true for timber and range management. Some treatment-cost information is available, but it frequently has been developed from limited case studies. These data cannot be extrapolated over major forest type or areas. There are also problems of data comparability which limit the usefulness of existing information for analytical purposes. Better information on costs of site preparation, tree planting, intermediate thinning, forest type conversion, and other silvicultural treatments is needed. Similar information is also needed for range and wildlife habitat treatment practices.

Surveys of Forest and Range Product Prices

At present, some dozen States publish periodic reports (quarterly, semiannual, or annual) on prices of timber products. These vary in coverage but most include data on the selling price of stumpage (standing timber) and the important primary products in the State such as saw logs, veneer logs, pulpwood, poles, and posts. Data on the average stumpage prices of standing timber sold from the National Forests by major species and region are published on a quarterly basis by the Forest Service.

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The data currently available on prices provide useful marketing guides and generally facilitate improved management and utilization of timber stands in the reporting States. However, because of the limited geographic coverage and deficiencies in the content, frequency, accuracy, and coverage, the published data are generally not adequate for meeting the price needs of timber owners and forest land managers.

Systematic and statistically reliable price reporting on stumpage and important primary products in all forested areas would have many benefits. Such reporting would provide the millions of small timber owners with the information necessary for marketing standing timber and cut products and a base for calculating probable returns from various kinds of management practices. It would also provide information necessary for the efficient allocation of the more than $1 billion spent annually on the development, management, and protection of the Nation's forest and range lands.

Collecting Data and Scientific Information

The discussion so far has been concerned with scientific information and data needs. There are closely related needs to improve the techniques used in collecting statistically reliable inventory and use data; projecting longrun trends in demands and supplies of products; measuring responses to management; estimating the economic, social, and environmental impacts of changes in demand-supply relationships; and establishing management goals and objectives.

Conducting Inventories of Renewable Resources

Most surveys of forest, range, and inland water resources are based upon a low-intensity selected sample which will only provide valid data for relatively large areas or volumes. Research is needed on ways of obtaining reliable data for relatively small areas and volumes while maintaining the low-intensity sampling. Research is also needed to develop concepts and techniques for linking a resource inventory system with comprehensive land classification systems to enable better analysis of production opportunities and impacts of local management alternatives and national programs.

In addition to this general work, there are several high priority categories of research that are needed to improve techniques for conducting renewable resource inventories.

For example, there is a great deal of sampling theory available and wide experience in applying this theory in timber resource surveys. However, very little is known about the application of these or alternative procedures in surveying other resources. In addition, little is known about sampling procedures for multiresource inventories done simultaneously across resources systems. There may be substantial savings in cost, as well as increases in the value of the information, if multiresource sampling procedures can be developed.

At this time, there is not a generally satisfactory scientific method for determining the levels of precision needed in the data used as a base for decisions on resources management activities. Research on the effects of errors of various sizes might provide useful concepts and procedures for determining precision standards. Such concepts and procedures would also provide a basis for choosing among alternative inventory procedures, and for determining how far to carry local intensifications of surveys.

It is evident that there is a need to shorten the time interval between resources inventories so as to increase the reliability and usefulness of the information. One approach that shows promise for maintaining continuity and reliability of inventories over time is to exploit the relationship between successive surveys through a technique called sampling with partial replacement. Research, followed by applied experience in Forest Survey, has shown this to be useful for the timber resource. However, additional research is needed to develop this or alternative techniques for the other resource systems and the multiresource system. Further research is also required to determine the time interval and the sample replacement policy that would be best for simultaneous sampling of all resources.

There is also a need to carry on research on ways of determining the availability of existing resources for use by consumers. For example, substantial parts of the existing wildlife, timber, and forage resources cannot be used because of economic or physical inaccessibility, or landowner objectives which are not compatible with uses such as hunting or fishing, timber harvesting or grazing.

Conducting Surveys of Use of Renewable Resources

Most of what has been said about inventory research needs could be repeated with respect to surveys of the use of these resources. There are, however, some differences and some additional needs here. Surveys of use of renewable resources must usually be done at the point of manufacture of products from raw materials provided from the resource systems or at the point of consumption of a service such as recreation. Some information about raw materials use is usually available from a variety of sources. Hence, the major difficulty may be one of

developing sampling techniques to estimate information not available, or developing estimation techniques that integrate to a reliable whole the partial estimates from all sources.

Methodology is available and is being applied to determine the kinds and amounts of raw material used in construction, manufacturing, and shipping. And there are highly developed procedures for deriving questionnaires, selecting samples, and analyzing survey results. However, research is needed to develop theory and methods to cost-effectively estimate use for each of the resource systems and for the multiresource system. Surveys have the same requirements as inventories in that they must produce estimates of use on a local basis for managerial decisions and which can be compiled into regional and national totals.

From past research, there are conversion factors for relating volumes of manufactured timber products such as lumber, plywood, and woodpulp to estimates of the amount of removals from timber inventories. But further research is needed to improve these conversion factors. Further research is also needed on ways of estimating primary product yields from standing trees and the loss of materials in logging and plant residues.

There are related and more difficult problems requiring research in the other resource systems. For example, there are particular difficulties in determining the nonconsumptive uses of wildlife. Similarly, research is needed to develop better ways to measure the output of the recreation and wilderness resource systems and to estimate use of outputs. Work is especially needed on ways of measuring the less tangible outputs and uses of the forest and range land resources systems such as the esthetic values.

Projecting Longrun Trends in Demands and Supplies

Projections of demand for forest, range, and inland water products, along with projections of supply, are necessary for appraising opportunities for economic development of renewable resources and the formulation and guidance of management policies and programs.

Adequate methods have been developed to project longrun trends in demands for timber, forage, and water. Methodology for projecting demands for developed recreation is more limited and there are few tools for projecting demands or social needs for wilderness, many types of recreation, and fish and wildlife. Thus, there is need to begin research on methods for projecting demands for those products and knowledge of the effects of various demand determinants such as population and income growth, technological changes, and energy costs.

Price is a particularly important determinant of demand for many products and a subject area in special need of more research. The relationship between price and amount demanded is measured by the elasticity of demand. Timber is the only product where past research provides some indication of the elasticity of demand. Additional knowledge on price elasticity would provide a basis for estimating the impact of price changes on the consumption of various products. It would also provide insights into the stability of demand for certain commodities and services and the propensity to shift to substitute goods and services.

The methodology available for projecting supplies of forest, range, and inland water products is much more primitive than for demand. For some products—such as outdoor recreation, hunting, and fishing—there is only limited and fragmented information on current supplies, and no operational techniques for assessing either shortrun or longrun supply trends. Because of the limited technology now available and the importance of demand-supply projections in guiding economic development and management policies, there is urgency in getting work underway on the development of methods and techniques for projecting supplies and particularly for such major products as timber. There is a related need to determine the various forces affecting supplies and establishing relationships to changes in supplies.

Impacts of Changes in Management and Demand-Supply Relationships

Substantive changes in management and/or demands and supplies of forest, range, and inland water products are likely to have significant economic, social, and environmental impacts. Present methods for assessing these impacts are poorly developed and there is no general consensus on which impacts are relevant and should be considered and quantified. Probably the first research should be to determine the relative importance of potential impacts. Once identified, research could then develop methods for quantifying and evaluating those that are most significant.

There is a related need for research on techniques for assessing the esthetic impacts of programs and practices which result in physical changes in the landscape. Timber harvesting, recreation development, and range rehabilitation all change the esthetic character of the area in which they are applied. Yet, at this time, little is known about the metrics for estimating change in the esthetic character of landscapes. In addition, there is presently no way of aggregating esthetic impacts which may result from the implementation of national programs.

In determining economic, social, and environmental impacts, there is a major problem in developing compatible units of measure for program inputs and outputs. Presently, there is no alternative to the various genetic measures in common use. Since these measures are usually noncomparable (e.g., animal unit months of grazing and cubic feet of timber production) they cannot be summed and trade-off analyses are difficult or impossible. Hence, research is needed to develop concepts and techniques for overcoming this difficulty of incommeasurability.

The reliability of estimates of inputs and outputs of programs can only be tested against the actual performance that results when the programs are implemented. Hence, a monitoring and feedback system must be created. Research is needed to develop concepts and procedures for production monitoring, cost accounting, and feedback to provide timely and reliable data for program guidance.

Establishing Goals and Objectives

Identifying economic, social, and environmental goals and using them to guide public programs is difficult and far from an exact science. Making decisions on the management and use of renewable resources, however, unavoidably implies that such goals have been determined.

Societal goals, expressed by legislators, industry, and other interested groups and organizations are usually rather general statements. Developing procedures for translation of those general goal statements into program elements and corresponding quantities or targets for various administrative units is long-term research that should have high priority. For a geographically dispersed land resource this problem is made even more difficult since local management must reflect both local and national needs. This research in goal establishment requires identification of the many clientele of renewable resource programs, how they are affected by management decisions, and how these relate to national goals.

The goal identification problem is broad in geographic and institutional scope. In addition to relying on administrative and legislative sources for goal determinations, contemporary tradition and law requires the Forest Service and other agencies to go to the people for direct input of their goals and values through the public involvement process.

Many public involvement processes are currently in use by the Forest Service and other Federal and State agencies. Only little research is in progress on most effective means for public involvement in setting renewable resource management goals. To advance further, these involvement processes have to be identified by the operational variables of the process itself (e.g., publics, focus, purpose, process, products, etc.) and the characteristic variables of the land management problem on which involvement focuses.

GLOSSARY

Aggregated subarea. Subdelineations of Water Resource Regions—also based upon hydrologic boundaries.

Animal unit months (AUM's). Amount of grazing required by a mature cow for 1 month.

Commercial timberland. Forest land producing or capable of producing crops of industrial wood and not withdrawn from timber utilization. (Note: Areas qualifying as commercial timberland have the capability of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included, except when the areas involved are small and unlikely to become suitable for production of industrial wood in the foreseeable future.)

Consumptive water use. Portion of water withdrawn that is consumed through evaporation, transpiration, or discharge into irretrievable locations.

Cropland. Land under cultivation within the past 24 months, including cropland harvested, crop failures, cultivated summer fallow, idle cropland used only for pasture, orchards, and land in soil improving crops, but excluding land cultivated in developing improved pasture.

Cropland pasture. Land used for grazing that has been used for crops within the last 5 years.

Deferred forest land. National Forest land that meets productivity standards for commercial timberland, but is under study for possible inclusion in the Wilderness System.

Developed (or concentrated) recreation. Outdoor recreation requiring significant capital investment in facilities to handle a concentration of visitors on a relatively small area.

Dispersed recreation. Outdoor recreation in which visitors are diffused over relatively large areas. Where facilities or developments are provided, they are more for access and protection of the environment than for the comfort or convenience of the people.

Domestic water use. Water used for drinking, sanitation, street flushing, fire protection, and lawn and garden irrigation.

Ecosystem. Natural plant community that would exist in an area if it were undisturbed by man or natural agents.

Endangered species. Any species of animal or plant which is in danger of extinction throughout all or a significant portion of its range.

Farm. A place of 10 or more acres from which the sale of agricultural products totaled $50 or more annually, or a place of less than 10 acres from which the sale of agricultural products totaled $250 or more during the previous year.

Farm and miscellaneous lands. Privately owned lands other than in forest industry ownership.

Forage. The herbaceous and woody vegetation available and suitable as food for livestock and game animals.

Forest land. Land at least 10 percent occupied by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. (Note: The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams, or other bodies of water or clearings in forest areas are classed as forest if less than 120 feet in width.) Also see definitions for land area, commercial timberland, noncommercial forest land, productive-reserved forest land, stocking, and unproductive forest land.

Forest site productivity class. A classification of forest land in terms of potential cubic-foot volume growth per acre at culmination of mean annual increment in fully stocked natural stands.

Forest type. A classification of forest land based upon the species forming a plurality of live-tree stocking. Type is determined on the basis of species plurality of all live trees that contribute to stocking.

Growing-stock volume. Net volume in cubic feet of growing-stock trees 5.0 inches d.b.h. and over from a 1-foot stump to a minimum 4.0-inch top diameter outside bark of the central stem or to the point where the central stem breaks into limbs.

Hardwoods. Dicotyledonous trees, usually broad-leaved and deciduous.

Highest site productivity class. Lands capable of producing 120 cubic feet or more of timber per acre per year.

Industrial wood. All roundwood products, except fuelwood.

Inland waters. Lakes, reservoirs, and ponds over 40 acres in size and streams more than 1/8 mile in width.

Land area.

a *Bureau of the Census.* The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river flood plains (omitting tidal flats below mean high tide); streams, sloughs, estuaries, and canals less than 1/8 of a statute mile in width; and lakes, reservoirs, and ponds less than 40 acres in area.

b *Forest Survey*. Same as the Bureau of the Census except minimum width of streams, etc., is 120 feet and minimum size of lakes, etc., is 1 acre.

Logging residues. Unused portions of trees (included in growing-stock inventories) cut or killed by logging.

Lowest site productivity class. Land capable of producing 20 to 50 cubic feet of timber per acre per year in fully stocked natural stands.

Mortality. Number or sound-wood volume of live trees dying from natural causes during a specified period.

Multiple-use management. The management of land resources aimed at achieving optimum yields of products and services from a given area without impairing the productive capacity of the site.

National Forest System lands. Federal lands which have been legally designated as National Forests or purchase units, and other lands under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III lands.

National Scenic Trails. Extended, continuous trails selected and developed because of their superior scenic, historical, natural, or cultural qualities.

National Recreation Trails. Continuous trails generally located close to urban areas to provide easy access to various outdoor recreation uses.

Net annual growth. The increase in volume of trees during a specified year. Components of net annual growth include the increment in net volume of trees at the beginning of the specified year surviving to its end, plus the net volume of trees reaching the minimum size class during the year, minus the volume of trees that died during the year, minus the net volume of trees that became rough or rotten trees during the year.

Net volume in board feet. The gross board-foot volume of trees less deductions for rot or other defect affecting use for lumber.

Net volume in cubic feet. Gross volume in cubic feet less deductions for rot.

Noncommercial forest land. (1) Unproductive forest land incapable of yielding crops of industrial wood because of adverse site conditions, and (2) productive forest land reserved for nontimber uses.

Noncommercial species. Tree species of typically small size, poor form, or inferior quality which normally do not develop into trees suitable for industrial wood products.

Nonforest land. Land that has never supported forests and lands formerly forested where use for timber management is precluded by development for other uses. (Note: Includes areas used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining clearings, powerline clearing of any width, and 1- to 40-acre areas of water classified by the Bureau of the Census as land. If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet wide, and clearings, etc., more than 1 acre in size, to qualify as nonforest land.)

Nonpoint pollution sources. Those diffuse sources that pollute receiving water as a result of a naturally occurring event, such as precipitation, seepage, runoff, and earthquakes, acting on a source area or tributary surface disturbed or affected by man's activities.

Nonstocked areas. Commercial timberland less than 10 percent occupied with growing-stock trees.

Off-road vehicles (ORV's). Motorcycles, all-terrain vehicles, fourwheel drives, and snowmobiles.

Phreatophyte. A deep-rooted plant which obtains its water from the water table or the layer of soil just above it.

Plant residues. Waste materials from the manufacture of lumber, plywood, and other wood products. Includes slabs, edgings, trimmings, miscuts, sawdust, shavings, veneer cores and clippings, and pulp screenings.

Point source of pollution. Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

Poletimber stands. Stands at least 10 percent occupied with growing-stock trees of which half or more of this stocking is in poletimber and/or sawtimber trees, and with poletimber stocking exceeding that of sawtimber.

Poletimber trees. Trees from 5 inches in diameter at breast height to sawtimber size, and now, or prospectively, suitable for industrial roundwood.

Productive-reserved forest land. Forest land sufficiently productive to qualify as commercial timberland, but withdrawn from timber utilization through statute or administrative designation.

Range. All land producing native forage for animal consumption, and lands that are revegetated naturally or artificially to provide a forage cover that is managed like native vegetation.

Rangeland. Lands on which the native vegetation (climax or natural potential) is predominately grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing use. Includes lands revegetated naturally or artificially to provide a forage cover that is managed like native vegetation.

Recreation visitor day. Twelve visitor hours, which may be aggregated continuously, intermittently, or simultaneously by one or more persons.

Removals. Volumes of timber removed from the growing-stock inventory, including timber products, logging residues, and other removal such as land clearing.

Roundwood equivalent. The volume of logs or other round products required to produce the woodpulp, paper, plywood, or other processed materials imported.

Sawtimber trees. Trees large enough to contain at least one log suitable for the manufacture of lumber.

Scenic rivers. Rivers or sections of rivers free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

Softwoods. Coniferous trees, usually evergreen, having needles or scalelike leaves.

Special interest areas. Areas described in the Environmental Policy Act of 1970 which include (1) cultural areas—historic or prehistoric sites and places of obvious future historical value, and (2) natural areas—outstanding examples of the Nation's geological and ecological features.

Stocking. The degree of occupancy of land by trees, measured by basal area and/or number of trees by size or age and spacing, compared to a stocking standard, i.e., the basal areas and/or number of trees required to fully utilize the growth potential of the land.

Stand improvement. Measures such as thinning, release cutting, girdling, weeding, or poisoning of unwanted trees aimed at improving growing conditions.

Supply confidence level. The water supply that would be exceeded in 50, 80, and 95 years out of 100.

Threatened species. Any species which is likely to become an endangered species in the foreseeable future throughout all or a portion of its range.

Unproductive forest land. Forest land incapable of producing 20 cubic feet per acre of industrial wood under natural conditions because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness.

Water-quality-limited. Classification of stream segments where the goals of the Federal Water Pollution Control Act Amendments of 1972 are likely to be met later than 1977.

Water resource region. The 21 major hydrologic regions into which the United States is delineated.

Wild rivers. Those rivers or sections of rivers free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive (and waters unpolluted).

Wilderness. An area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least 5,000 acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

Withdrawal use. Water that is taken from a source, used, and then returned to a source for reuse.

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